

Overview of Engineering Design and Analysis at the NASA John C. Stennis Space Center



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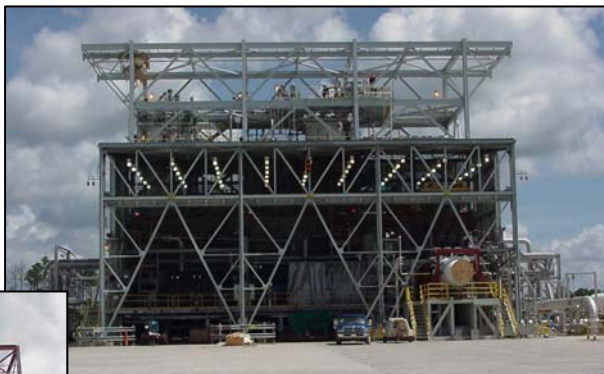
Mississippi Engineering Society Winter Meeting
Jackson, MS
February 27, 2007



Complete Suite of Test Capability and Expertise

E-1 Stand

High Press., Full Scale
Engine Components



E-2

High Press.
Mid-Scale
& Subscale

E-3

High Press.
Small-Scale
Subscale



A-1 ... Full Scale Engine Devt. & Cert ... **A-2**

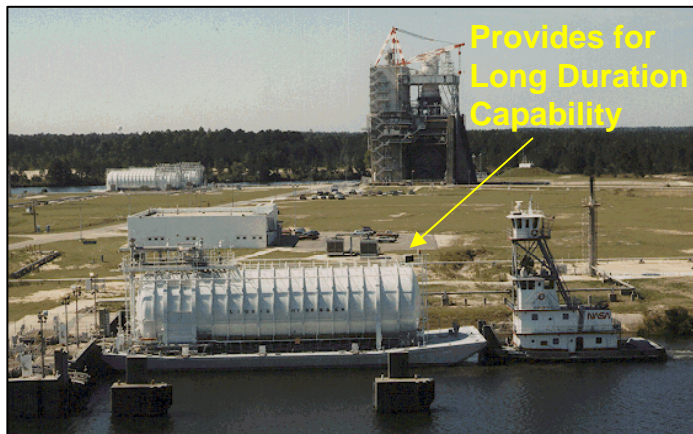


B-1/B-2 ... Full Scale Engine/Stage Devt. & Cert

Components ... Engines ... Stages



SSC Support Facilities



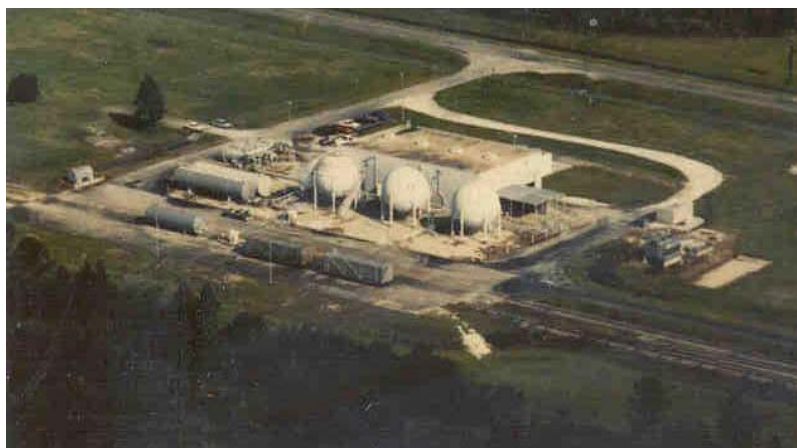
Cryogenic Propellant Storage Facility

Six (6) 100,000 Gallon LOX Barges
Three (3) 240,000 Gallon LH Barges



High Pressure Industrial Water (HPIW)

330,000 gpm Delivery System



High Pressure Gas Facility (HPGF)

(GN, GHe, GH, Air: ~ 3000 to 4000 psi)

Additional Support

- Laboratories
 - ✓ Gas and Material Analysis
 - ✓ Measurement Standards and Calibration
 - ✓ Environmental
- Shops
- Utilities

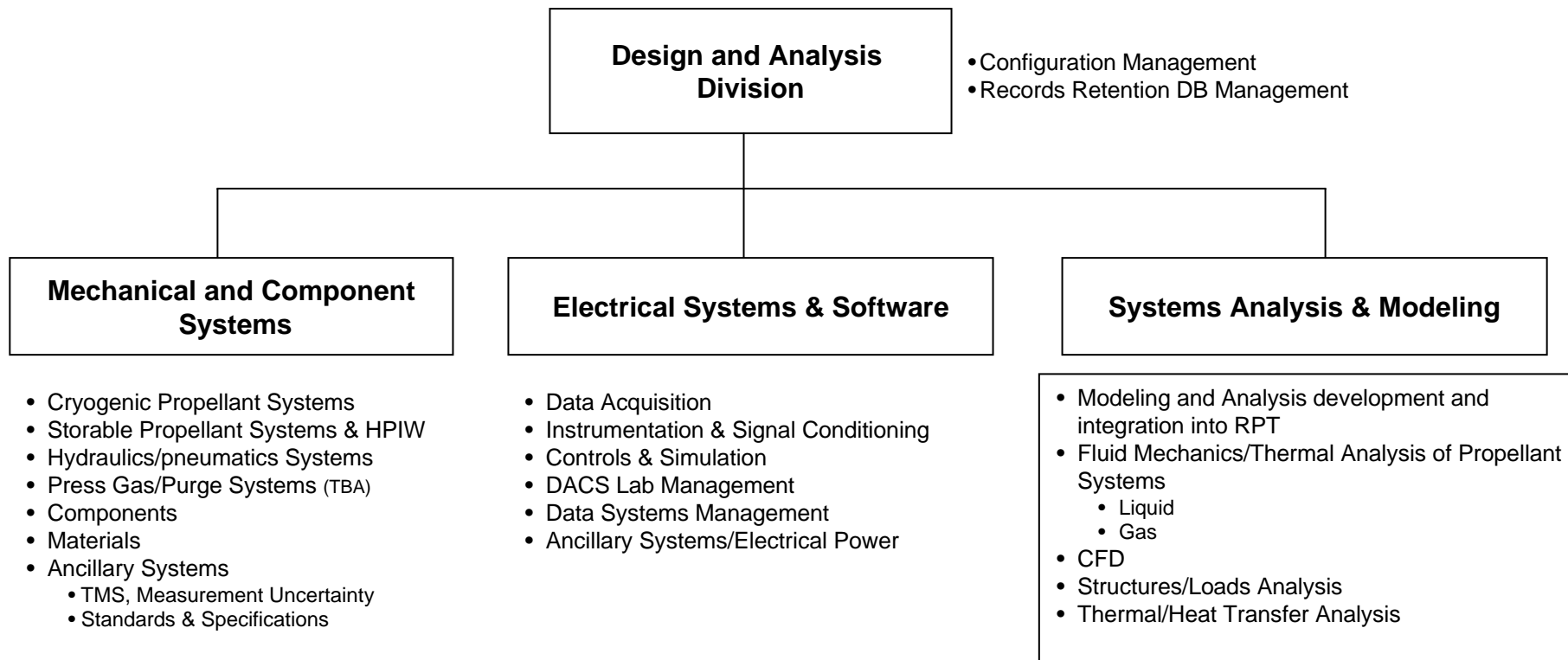


Propulsion Testing at the NASA John C. Stennis Space Center (SSC)

Video



NASA SSC Design & Analysis Division



Organization Goal:

- **Develop and maintain propulsion test systems and facilities engineering competencies**
 - Unique and focused technical knowledge across respective engineering disciplines applied to rocket propulsion testing. e.g.,
 - Materials selection and associated database management
 - Piping, electrical and data acquisition systems design for cryogenic, high flow, high pressure propellant supply regimes
 - Associated analytic modeling and systems analysis disciplines and techniques
 - Corresponding fluids structural, thermal and electrical engineering disciplines



Integrated Facility Simulation and Analysis

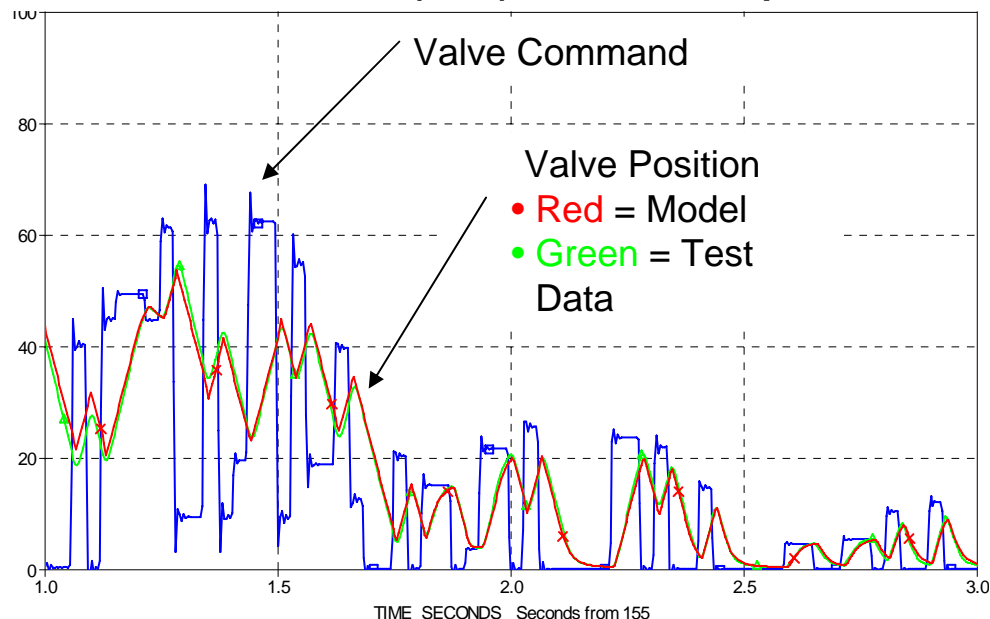
- To Support Propulsion Testing, SSC Has Developed & Implemented Analytic Modeling & Simulation Tools
 - Rocket Propulsion Test Analysis (RPTA) Model (FORTRAN) Used to Simulate Propulsion Test Facility Systems (e.g., LOX Run System)
 - ✓ Heritage of Model Dates to Pressurization and Propellant Systems Design Tasks for Space Shuttle and X-33
 - ✓ Model Adapted, Validated and Currently Used at SSC to Simulate Facility Pressurization and Propellant Systems
 - Computational Fluid Dynamics (CFD) Used for Select Propulsion Test Situations
 - Have Experienced Analysis Team that Routinely Solves Pressurization and Propellant System Problems
- Integrated Facility Simulation and Analysis Has Led to Substantial Project Cost and Schedule Savings



Rocket Propulsion Test Analysis (RPTA) Model

- Temporal Transient Thermodynamic Modeling of Integrated Propellant Systems
- Thermodynamic Control Volume Solver Model Accurately Models High-Pressure Cryogenic Fluids and High-Pressure Gaseous Systems. Model Features Include:
 - High-Fidelity Pressure Control Valve (PCV) & Closed Loop Control System Model
- RPTA Model Validated Through Test Data Comparisons
 - IPD Fuel Turbopump, RS-84 Sub-Scale Pre-Burner, RS-83 Pre-Burner Cold Flows, SSME Flowliner Activation & IPD Engine System

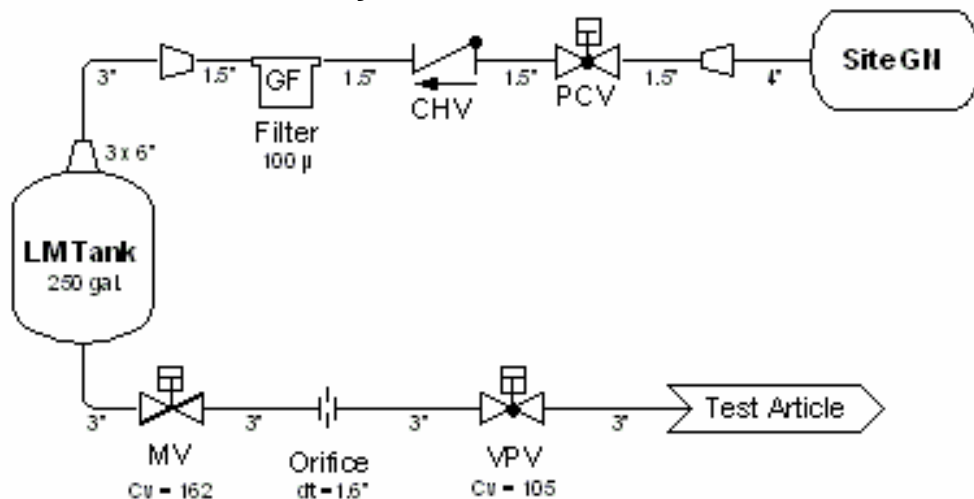
Pressure Control Valve (PCV) Model Developed & Validated



A Significant Advantage of the RPTA Model is the Coupling of Control Logic (Electro-Mechanical Process) with Thermodynamic Processes

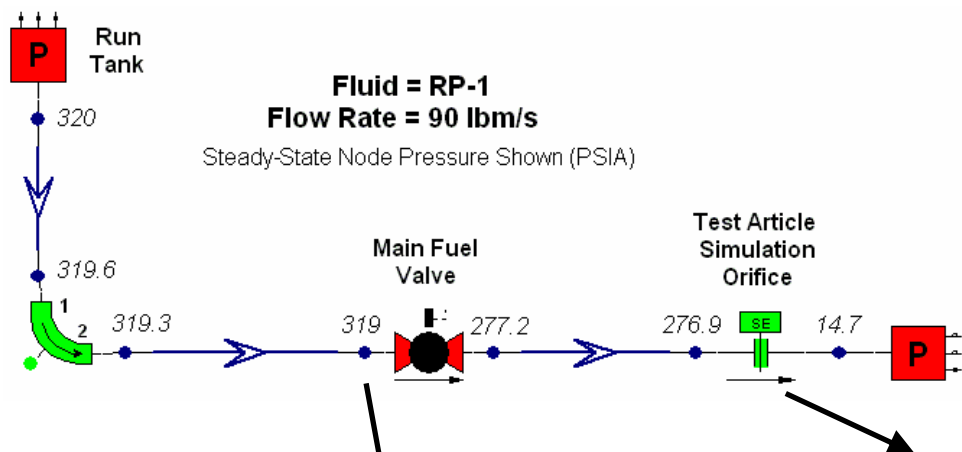


- **Liquid Methane (LM) & Liquid Oxygen (LOX) Propellants Used**
- **Facility Model Results and Facility Test Activation Results Agree Well**
- **Test Capability: ~25 seconds**

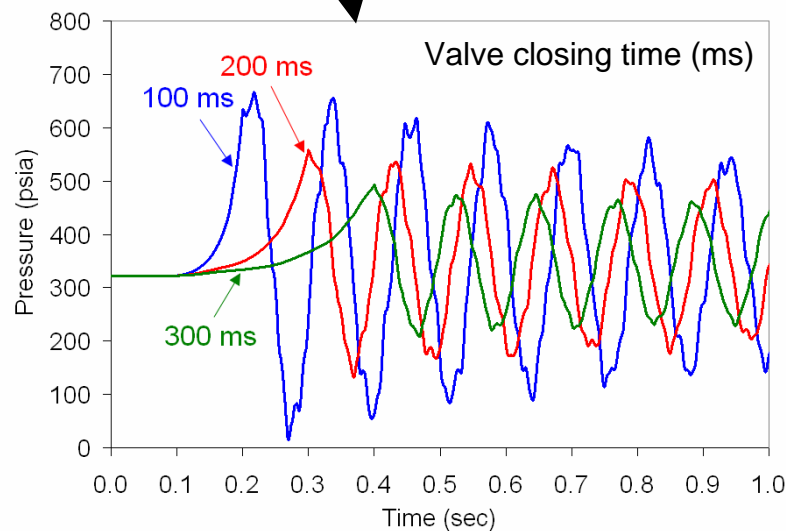




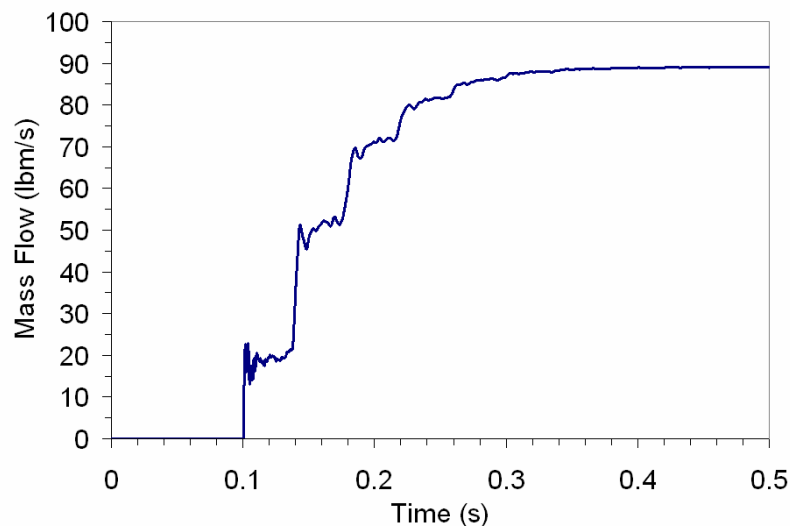
Comprehensive & Rapid Piping System Design & Analysis Capability



- Commercial Tools Employed to Augment Analysis
- Example: *FlowMaster* Piping System Analyzer
 - Allows for Steady-State or Transient Analysis, Compressible or Non-Compressible Flow
 - Includes Heat Transfer, Flow Balancing, Priming & Sizing Analysis



Water Hammer Effect Due to Rapid Closure of Main Fuel Valve



Propellant Flow to Test Article Due to Rapid Opening of Main Fuel Valve



Recent Project: Methane Technology Testbed Project (MTTP)

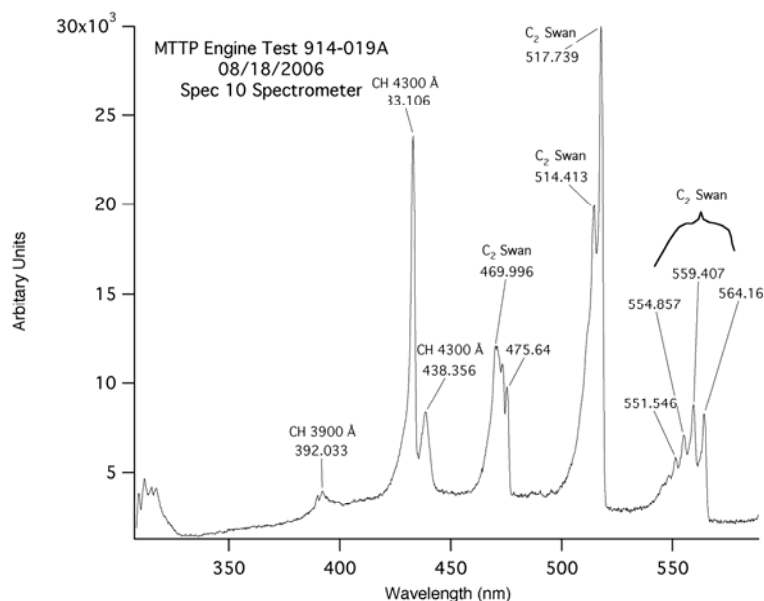
- MTTP provides portable, small-scale propulsion test capabilities
 - Can support gaseous methane, gaseous oxygen, liquid methane and kerosene-type propellants
 - Capable of supporting engines up to 1000-lbf thrust
- Tested 50-lbf thruster (right)
 - Plume diagnostics
 - Gained methane experience



Night firing of MTTP thruster



MTTP Test Skid



Exhaust spectrum for GOX/GM combustion



Recent Project: 14" Valve Test

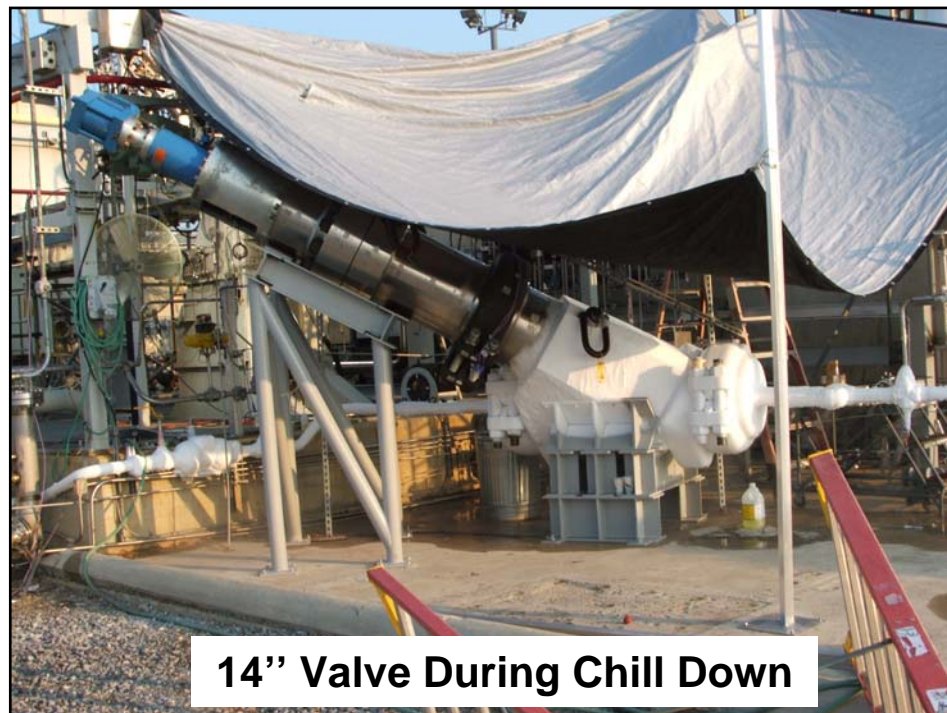
Description of Test Objectives

Test Objectives

- Collect Data Needed to Support a Decision to Install a 14" Valve (26,000 lb) on the E-1 Test Stand as the High Pressure (8,500 psi service) LOX Tank Isolation Valve
- Determine the Behavior of the Valve in Simulated Operating Conditions
- Determine the 14" Valve Bonnet and Body Steady State Temperatures

Test Details

- Conducted Valve Chill Down Test at the E-2 Test Stand
- Used Liquid Nitrogen (LN) to Chill Down the Valve
- Instrumented Valve with Multiple Thermocouples on the Valve Body and Stem
- During Chill Down Operations, the Valve was Cycled Multiple Times to Test Proper Valve Operation at Low Temperatures



14" Valve During Chill Down



14'' Valve Test Results

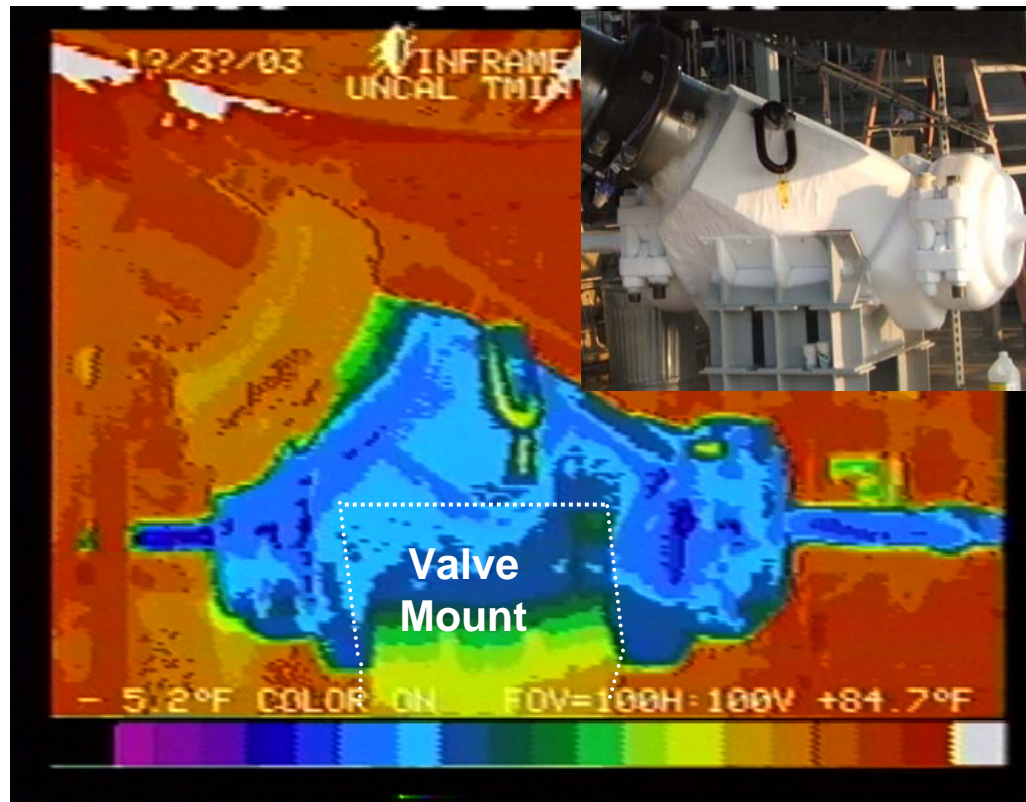
Test Results

- Test Lasted About 24 Hours
- About 6500 gal of LN Was Used for the Valve to Reach a Steady State Condition
- Boil Off Results Were Used to Calculate the Steady State Heat Load of the Valve

Analytical Accomplishments

- Identified Issue with Asymmetric Bonnet Wear at Cryogenic Temperatures
- Verified Analytical Predictions for the Heat Load of the Valve
 - Determined the Valve Heat Load
 - Determined the Valve Chill Down Time Constant
 - Test Results Will Be Used to Guide Bonnet Re-Design

Picture of Frost Line After 23 Hours of Chilling



Thermal Image of Valve After Test



14" Valve

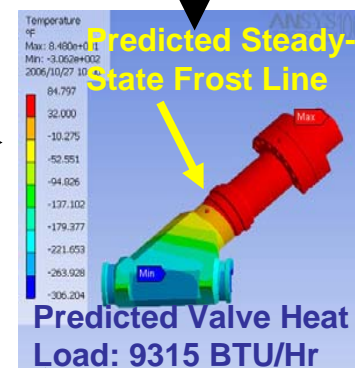
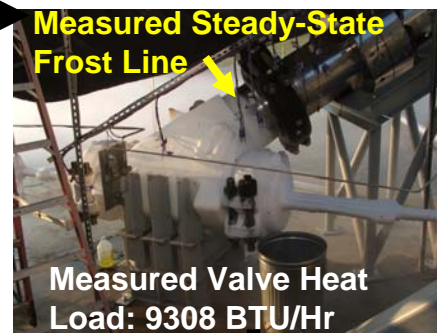
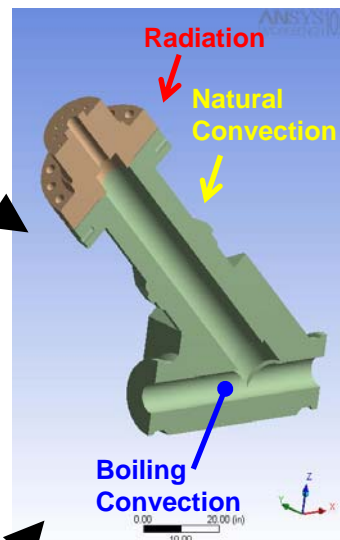
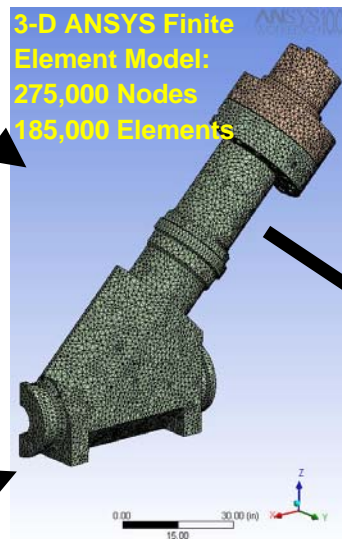
ANSYS Workbench Thermal Simulation

Geometry
Description

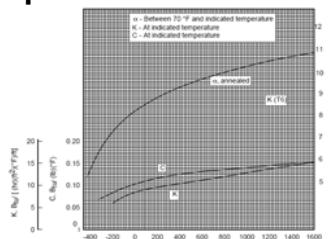
Analysis
Model

Loads & Boundary
Conditions

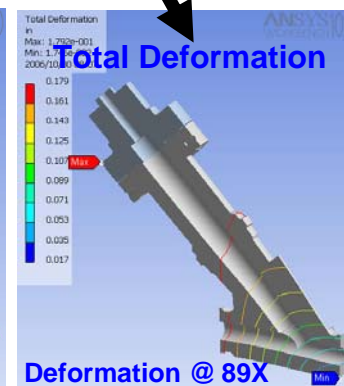
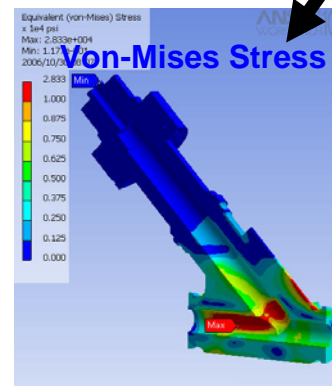
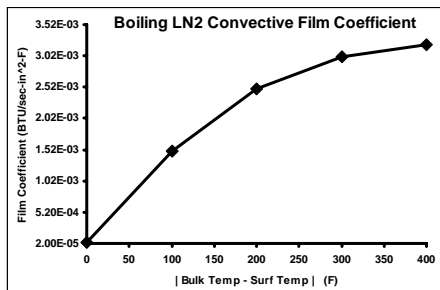
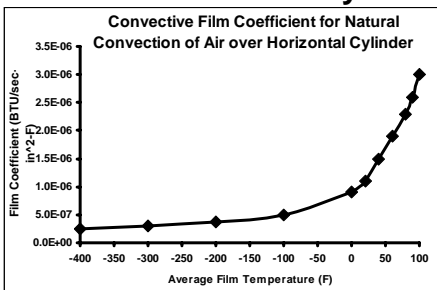
Validated Results



**NIST / MIL-HDBK Temperature
Dependent Material Properties**



**Empirically Based Temperature Dependent
Boundary Condition Parameters**



Deformation @ 89X



Computational Fluid Dynamics (CFD) Modeling

Employed CFD Code to Model E-1 High Pressure LOX Flow Capability

- CFD Investigations Indicate Pressurizing Gas Diffuser Flow Significantly Limits Flow Duration for High Flow Rate Cases

Analysis Boundary Conditions

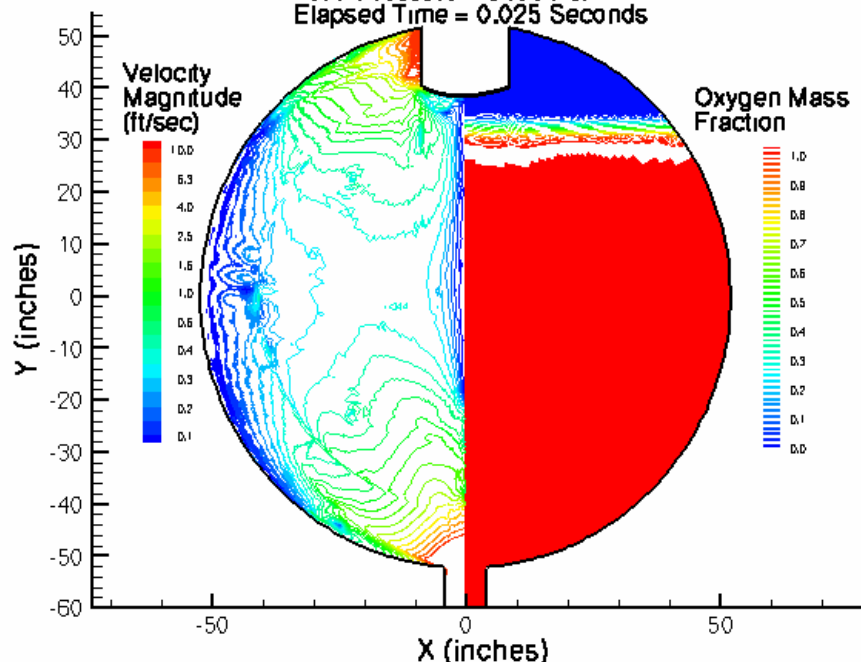
- HP LOX Tank at E-1 Test Stand
- Flow Case Assessed
 - 2500 lb/sec LOX Discharge Rate
 - 8400 psi Tank Pressure Maintained During Propellant Discharge

Results & Observations

- GN Convective Mixing with LOX Propellant is Substantial
 - Only 50% Loaded LOX is Useable (<~2% N₂ Concentration)
- LOX Propellant Supply at Assessed Flow Rate & Pressure Limited to Approximately 4 seconds (vs an Estimated 10 seconds Determined Using Nominal Facility Pressurizing Gas & Propellant Supply Limits)

HP LOX Tank Propellant Discharge Simulation

LOX Mass Flow Rate = 2500 lb/sec
LN₂ Mass Flow Rate = 1165 lb/sec
Tank Pressure = 8400 Psi
Elapsed Time = 0.025 Seconds



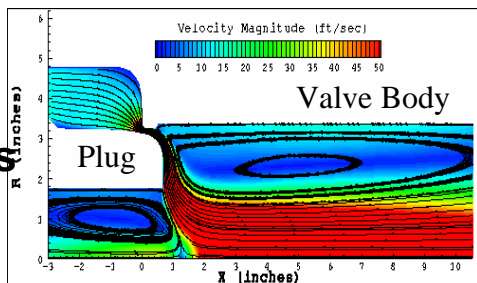


Computational Fluid Dynamics (CFD) Modeling

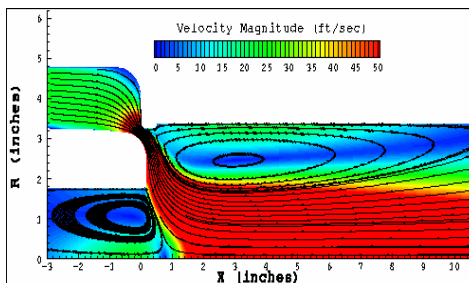
- Understanding a Valve's Flow Capacity (C_v) as a Function of Valve Stroke is Critical When Calculating the Propellant Flow Rates to a Test Article

Velocity & Streamlines

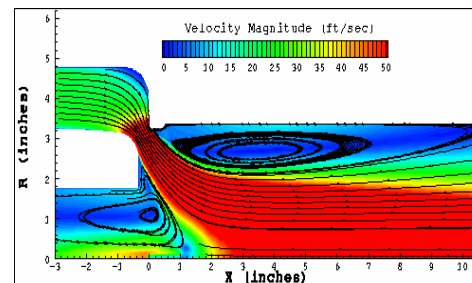
2.75" Stroke



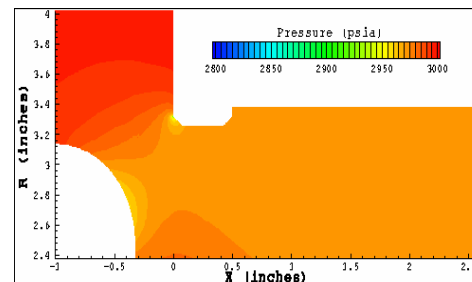
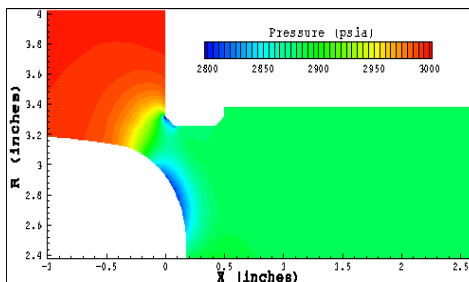
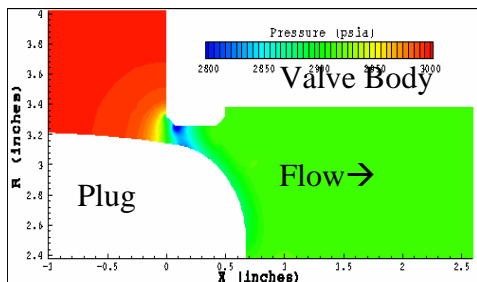
3.25" Stroke



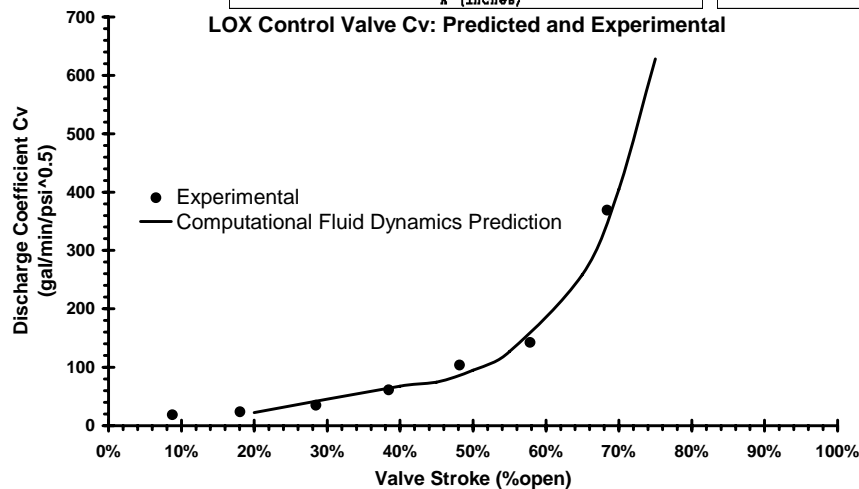
3.75" Stroke



Pressure



LOX Control Valve C_v : Predicted and Experimental



- CFD Used to Predict the Flow Field & C_v Curve for a Modified LOX Control Valve
- Yields a Good Understanding of How the Flow Field Changes as the Valve Opens & Affects C_v curve
- Analysis Reveals Areas Where Cavitation May Occur as Well as Areas of High Velocity That Are Important When the Working Fluid is LOX

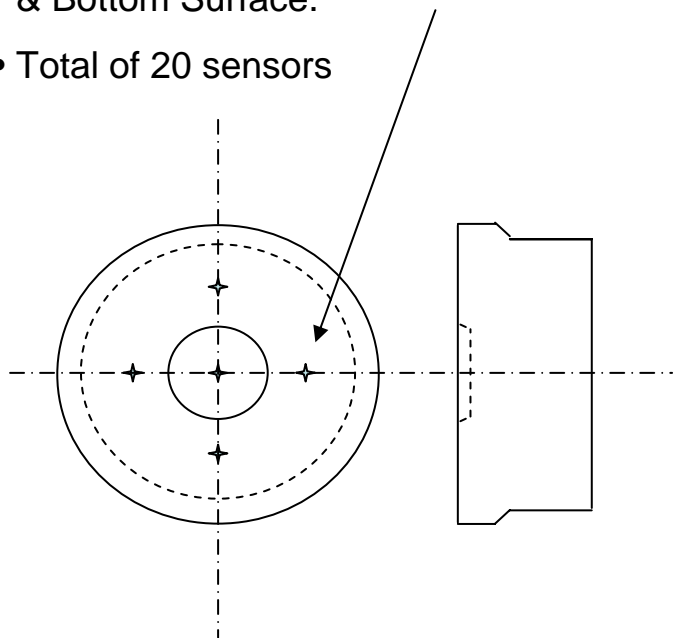


Thermal Fatigue Considerations

- The Goal of This Investigation Was to Simulate the Thermal Environment During Tank Chill Down and Apply What Was Learned in the Specimen Testing to Improve the Reliability of Analytical Model Calculations
- Performed Laboratory-Scale Testing

Test Specimen

- 5 Thermocouple & Strain Gage Pairs - 4 on 8" dia Spaced at 90°, 1 at Center. Typical on Both Top & Bottom Surface.
- Total of 20 sensors



Dye Penetration Testing

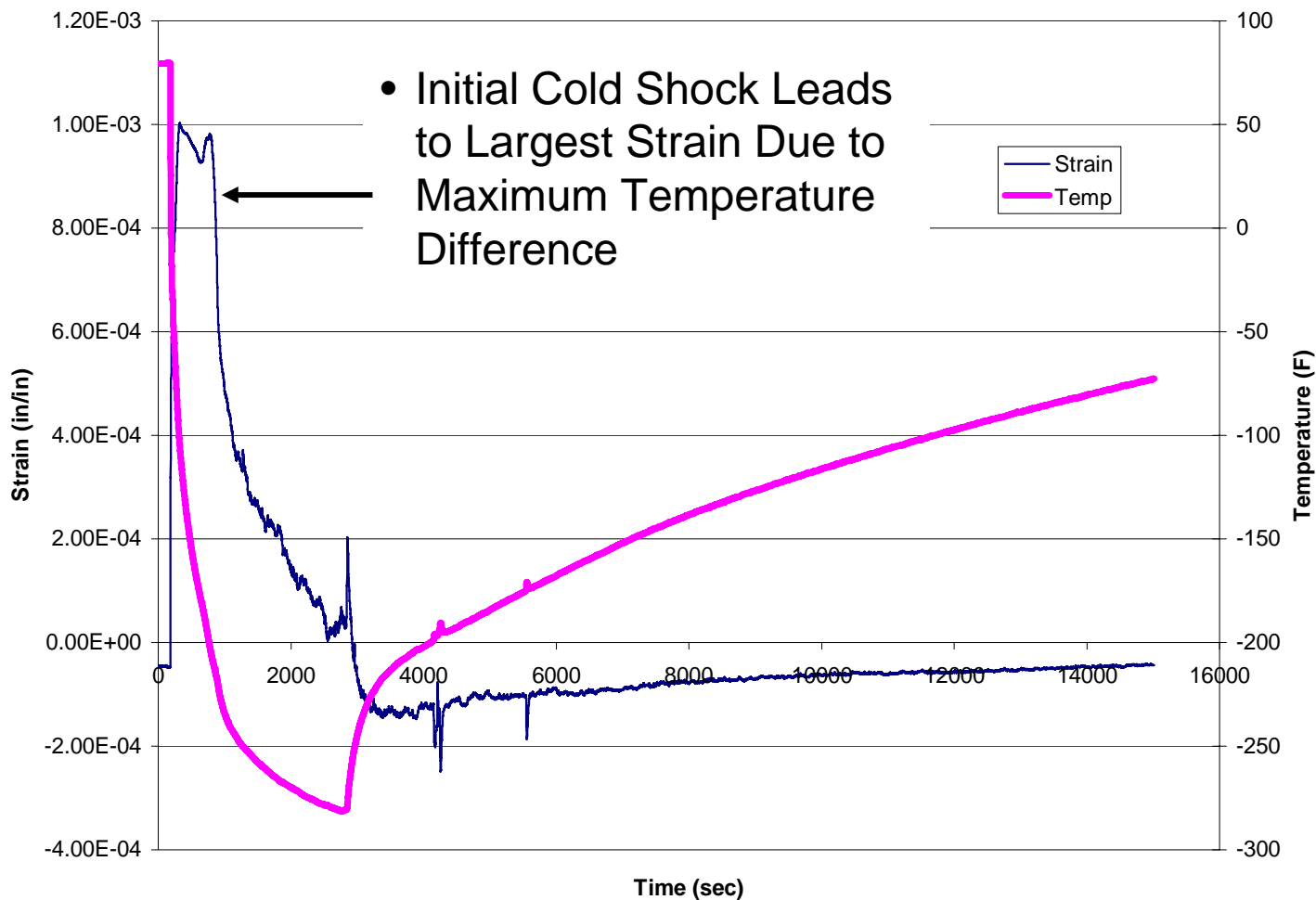
Test Procedure

- Subject Top of Test Specimen to LN
- Record Strain & Temperature Data
- NDE Dye Penetration Test Performed for Crack Detection
- Testing for Crack Initiation Made After Each Thermal Cycle for the First 15 Cycles
- Subject Test Specimen to Greater Than 100 Cycles



Thermal Fatigue Considerations

Top Center Temperature & Compensated Strain



Lab-Scale Specimen Exposed to LN



Summary

- SSC has Developed a Suite of Effective Analytic Modeling and Analysis Tools Providing High Fidelity Assessment of Test Stand Performance
 - Rocket Propulsion Test Analysis (RPTA) Model, a 1-D Propellant System Analyzer
 - CFD Applied to Select Propulsion Test Situations
 - Finite Element Analysis (ANSYS/CFX)
- Analytic Tools Exercised Regularly on a Variety of Propulsion Test Projects by Experienced Analysts
 - Active Test Facilities (1.0 to 1.5 Mlbf Thrust, 8500 psi LOX/LH/RP-1 Supply)
 - Active Test Projects (e.g., J-2X PPA, J-2X at PBS, TGV)
- We are Planning to Augment our Staff
 - Fluid Mechanics/Systems Modeling & Analysis
 - Thermal Analysis

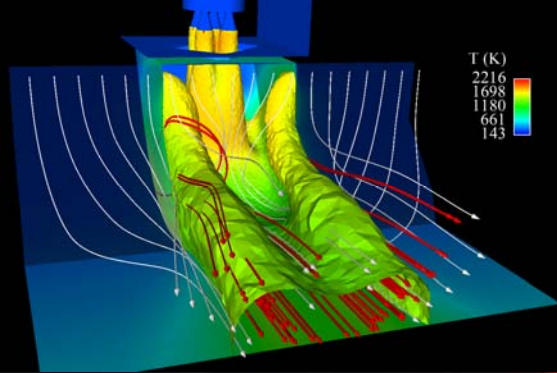
For Additional Information/Discussion Please Contact :

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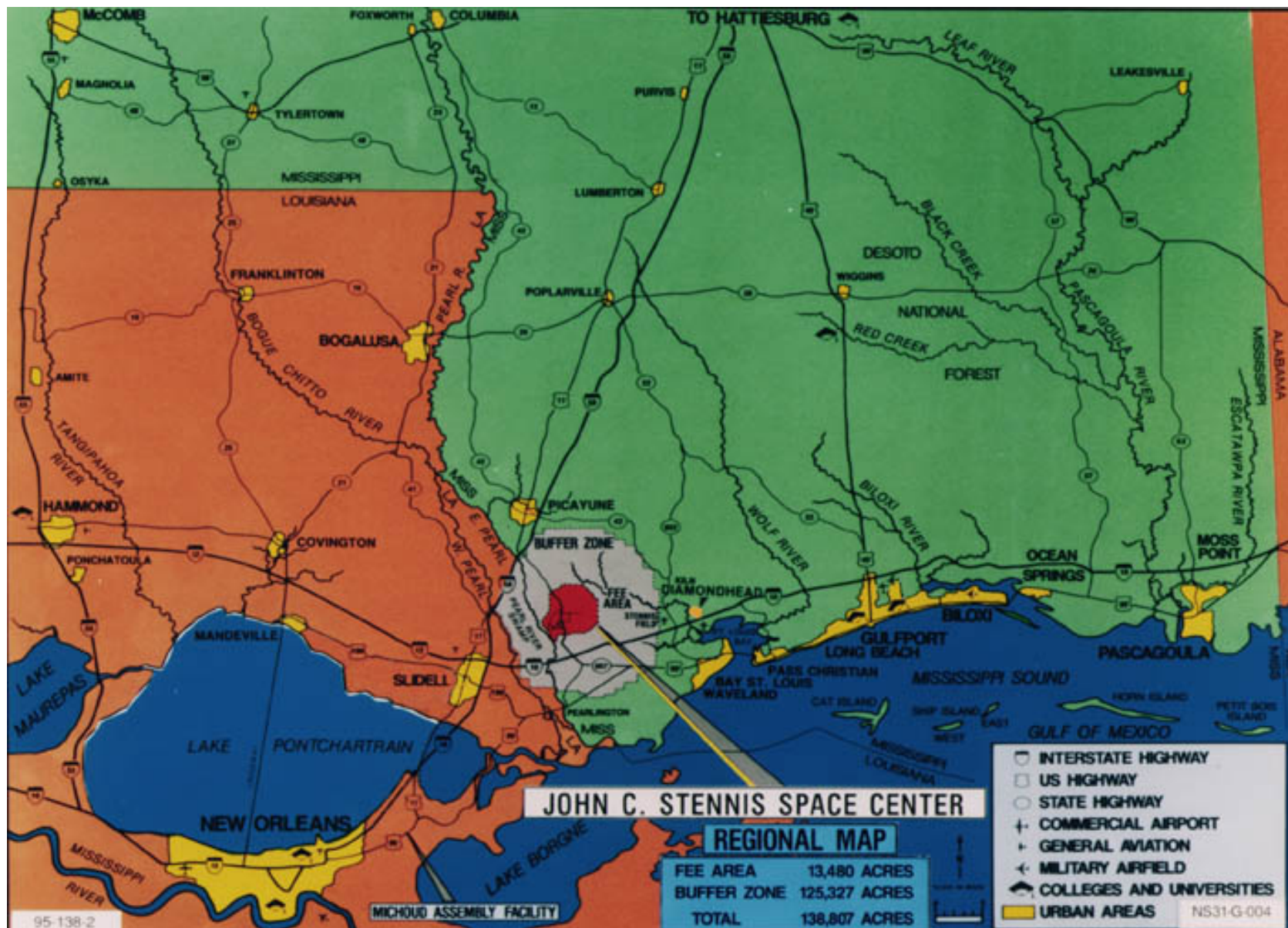
Arnold Association of Professional Societies (AAPS) Luncheon
Tullahoma, TN

January 21, 2009



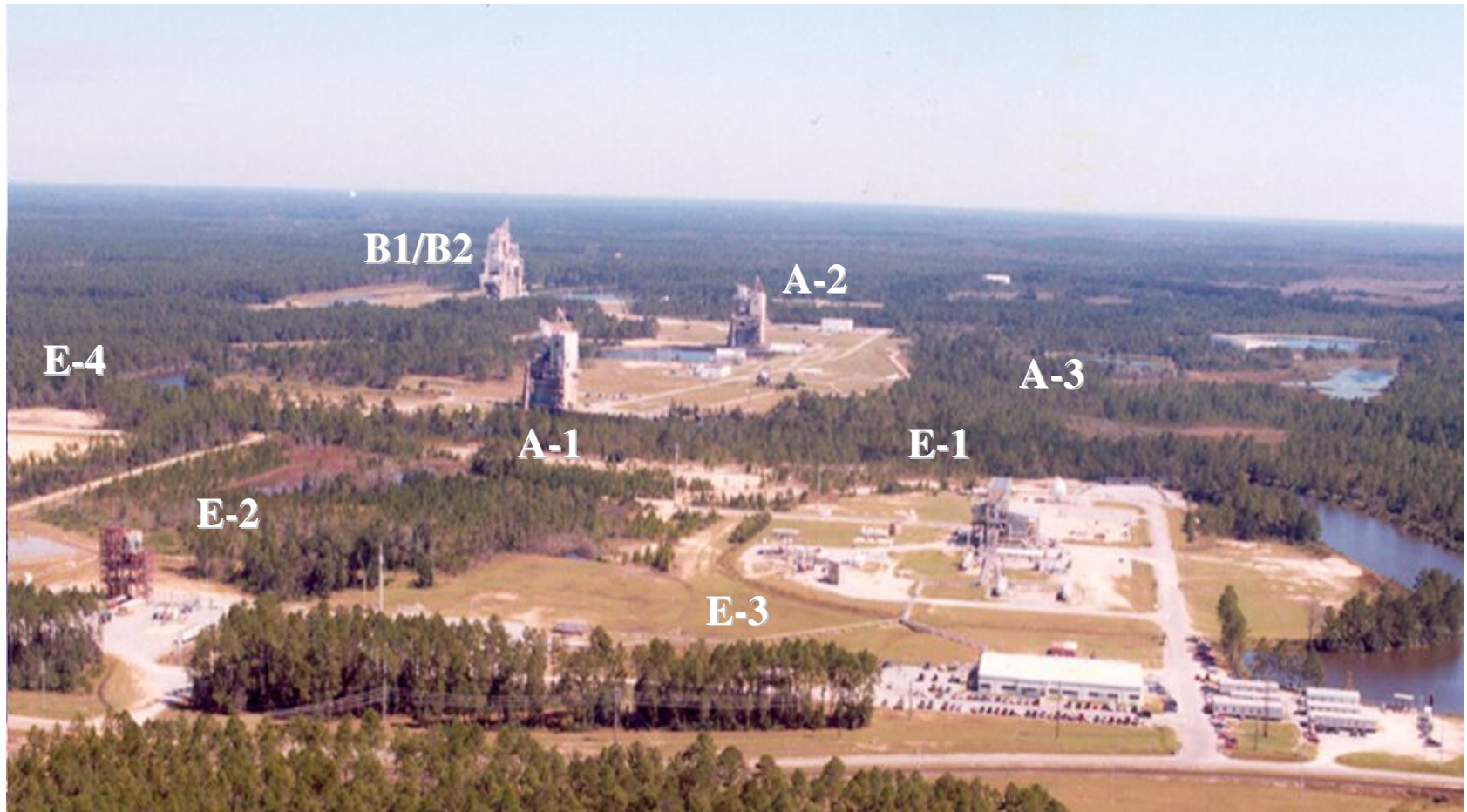


SSC Regional Map





Facilities & Operations



SSC's ETD (Engineering and Science Directorate) manages, develops, and operates SSC Rocket Propulsion Test (RPT) capabilities and facilities



Complete Suite of Test Capability and Expertise

E-1 Stand

High Press., Full Scale
Engine Components



E-2

High Press.
Mid-Scale
& Subscale

E-3

High Press.
Small-Scale
Subscale



A-1 ... Full Scale Engine Devt. & Cert ... **A-2**



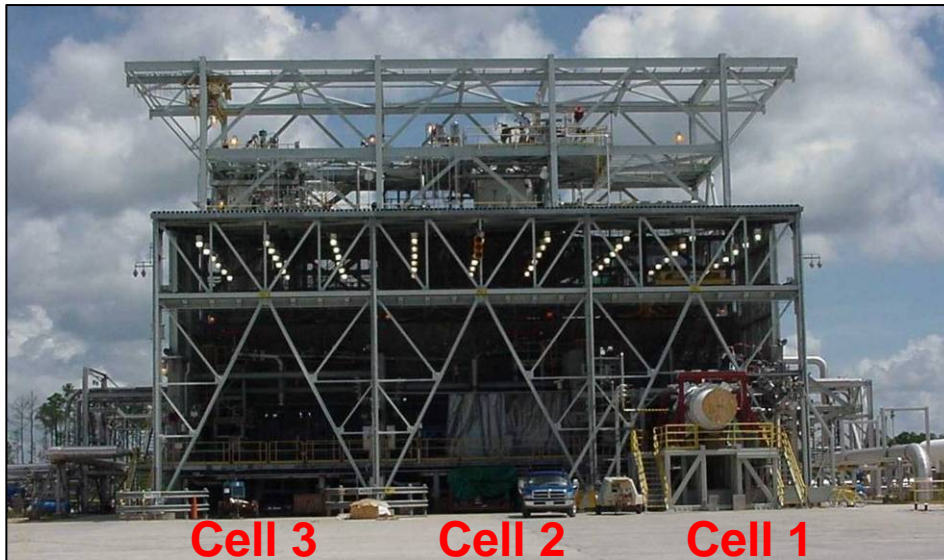
B-1/B-2 ... Full Scale Engine/Stage Devt. & Cert

Components ... Engines ... Stages



NASA-SSC Test Facilities – E Complex

Component and Engine Testing (E-1)



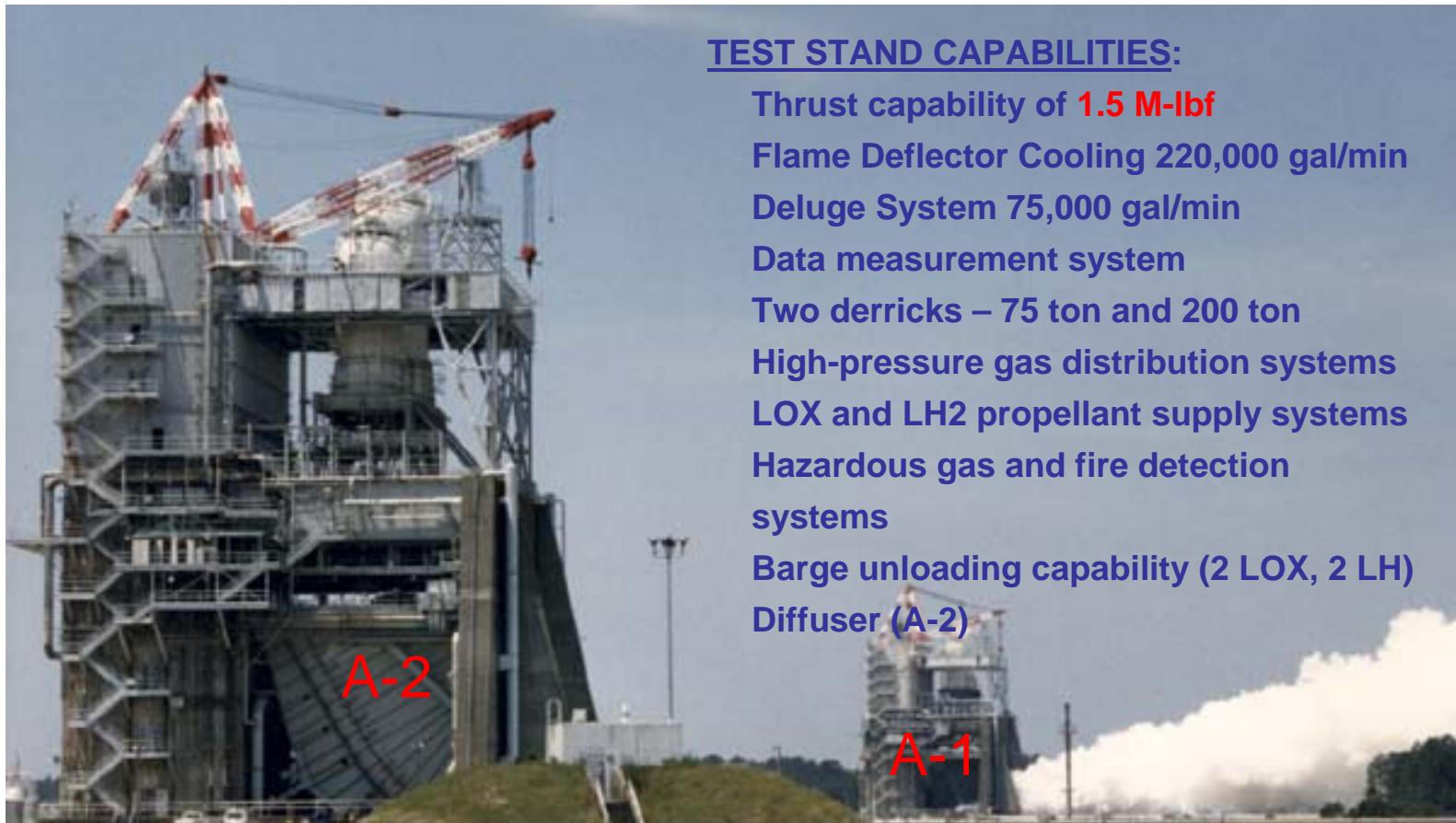
- High Pressure (Long Run) Capabilities
 - LOX/LH/RP ~ 8,500 psi
 - GN/GH ~ 15,000 psi
 - GHe ~ 10,000 psi
- State-of-the-Art DAC Systems
- E-1 Cell 1
 - Primarily Designed for Pressure-Fed LOX/LH/RP & Hybrid Test Articles
 - Thrust Loads up to **750K lb_f** (horiz.)
- E-1 Cell 2
 - Designed for LH Turbopump & Preburner Assembly Testing
 - Thrust Loads up to **60K lb_f**
- E-1 Cell 3
 - Designed for LOX Turbopump, Preburner Assembly & Engine Testing
 - Thrust Loads up to **750K lb_f**



NASA-SSC Test Facilities – A Complex

□ Full-scale Engine Development & Certification

- Saturn V 2nd Stage J-2 engine (1.15 M-lbf cluster of 5 LH₂/LOX J-2 engines)
- SSME (375 K-lb LH₂/LOX) development, flight acceptance, & 65kft altitude (A-2)
- X-33 Aerospike



TEST STAND CAPABILITIES:

Thrust capability of **1.5 M-lbf**

Flame Deflector Cooling 220,000 gal/min

Deluge System 75,000 gal/min

Data measurement system

Two derricks – 75 ton and 200 ton

High-pressure gas distribution systems

LOX and LH₂ propellant supply systems

Hazardous gas and fire detection systems

Barge unloading capability (2 LOX, 2 LH)

Diffuser (A-2)



NASA-SSC Test Facilities – B Complex

❑ Vehicle Stage & Full-scale Engine Testing

- SATURN V (7.7 M-lbf cluster of 5 RP-1/LOX F-1 engines)
- SSME MPTA (1.1 M-lbf cluster of 3 LH₂/LOX SSME)
- Delta IV Common Booster Core (650 K-lbf LH₂/LOX RS-68 engine)

TEST STAND CAPABILITIES:

Thrust capability of **13 M-lbf**

Flame Deflector Cooling 330,000 gal/min

Deluge System 123,000 gal/min

Data measurement system

Two derricks – 175 ton and 200 ton

High-pressure gas distribution systems

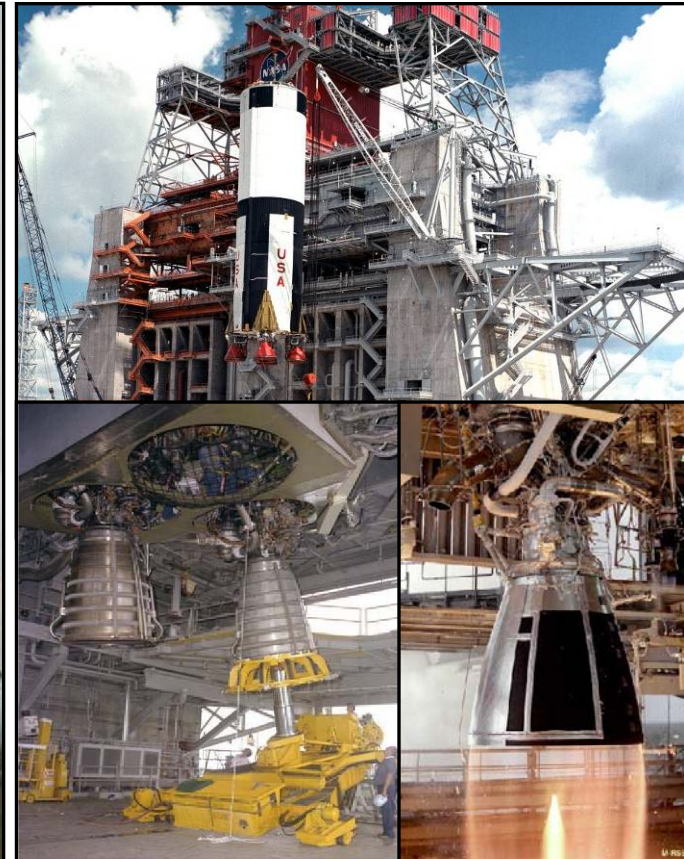
LOX and LH₂ propellant supply systems

Hazardous gas and fire detection systems

Barge unloading capability (3 LOX, 3 LH)

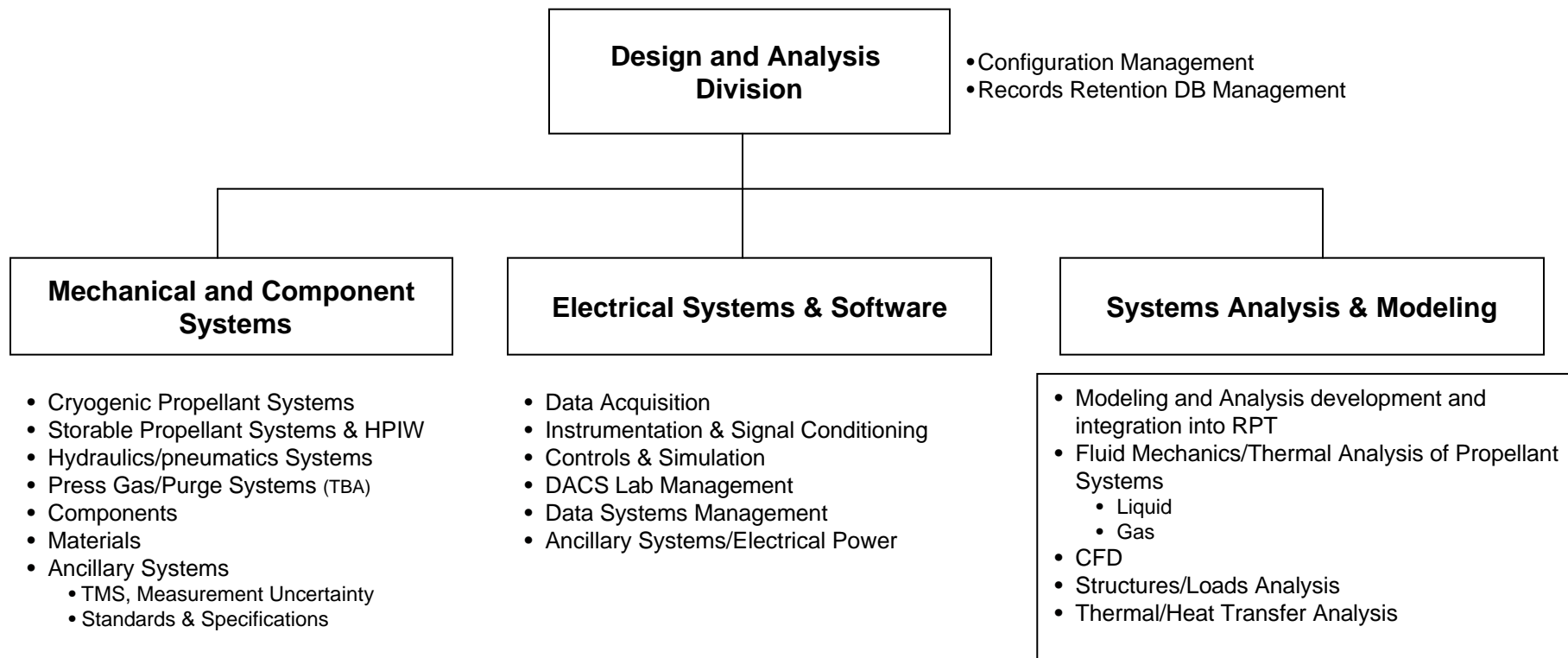
B-1

B-2





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 - Piping, electrical and data acquisition systems design for cryogenic, high flow, high pressure propellant supply regimes
 - Associated analytic modeling and systems analysis disciplines and techniques
 - Corresponding fluids structural, thermal and electrical engineering disciplines



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D&A Capability Development

Strengthening Engineering Competencies

- Structural Analysis
- Control Systems design/development
- Thermal Analysis/Heat Transfer
- Fluid Mechanics specific to RPT

Data Analysis Process Improvements

- Design & Data Management System
 - Record Retention System
 - Drawing Tree Development
 - Pro/E model MSK capability
 - A CM enhancement opportunity
- Wider access to analytic models
 - PSME Project
 - GUI
 - Server Access
- Internal Technical Reviews

SSC Design & Analysis Division

- RPTA Model
- CFD Crunch/FDNS
- MathCad/Excel Models

Analysis Tool Suite Growth

- Structural Analysis
 - **ANSYS/CFX**
- Purge systems design and analysis
 - **Flowmaster**
- Structural Heat Transfer/Thermal Analysis
 - **SINDA**
- Piping system modal analysis
 - **Autopipe**

Comprehensive Test Site Engineering Support

- **A,B & E Stand Modeling & Analysis**
 - J-2X, A3, Subscale Sim, Steam Gen Projects
- **Operations Support**
 - Test stand activation & test
- **Facility Operations Support, e.g.,**
 - LO2 Barge Impeller Structural Margin Def.
 - A1/A2 LH2 Vent Duct Rupture Invest, and Resolution
 - HPGN system redesign
 - HP Air System Contamination
 - LH2 Sphere Bypass Design
 - UT inspection of B Stand HP Water Deluge Sys

Expanding Beyond SSC E-Complex

- Ares US Propellant Tank Operations Performance Analysis Support to MSFC
- PBS B2 Test Stand Design
- RS-68 Test vs Flight Performance
- LSAM (JSC) & CEV SBT (GRC/NESC)



- Analytic Tools Available for Propulsion Test Facility Modeling & Analysis
- Comprehensive Propellant System Thermodynamic Modeling & Test Simulation

**GH2 Activation Test
June 29, 2004**

Modeling

Test and Data Analysis

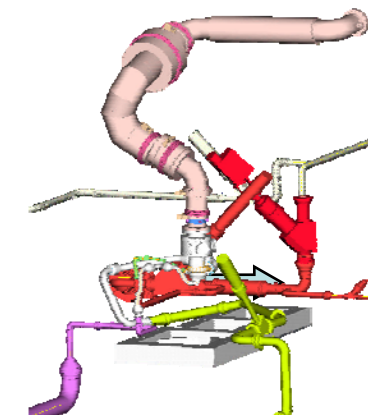


Figure 10 is a line graph showing Pressure (kPa) versus TIME (SECONDS) for the UHP Bottle Pressure, Mixer Pressure, and Interface Pressure. The UHP Bottle Pressure (red line with 'x' markers) starts at approximately 6200 kPa and decreases slowly to about 5000 kPa. The Mixer Pressure (green line with triangle markers) starts at 0, rises to a peak of about 5500 kPa at 208 seconds, and then drops sharply to 0 by 212 seconds. The Interface Pressure (blue line with square markers) starts at 0, rises to a peak of about 3800 kPa at 208 seconds, and then drops sharply to 0 by 212 seconds. The graph is labeled "Predicted vs Actual".

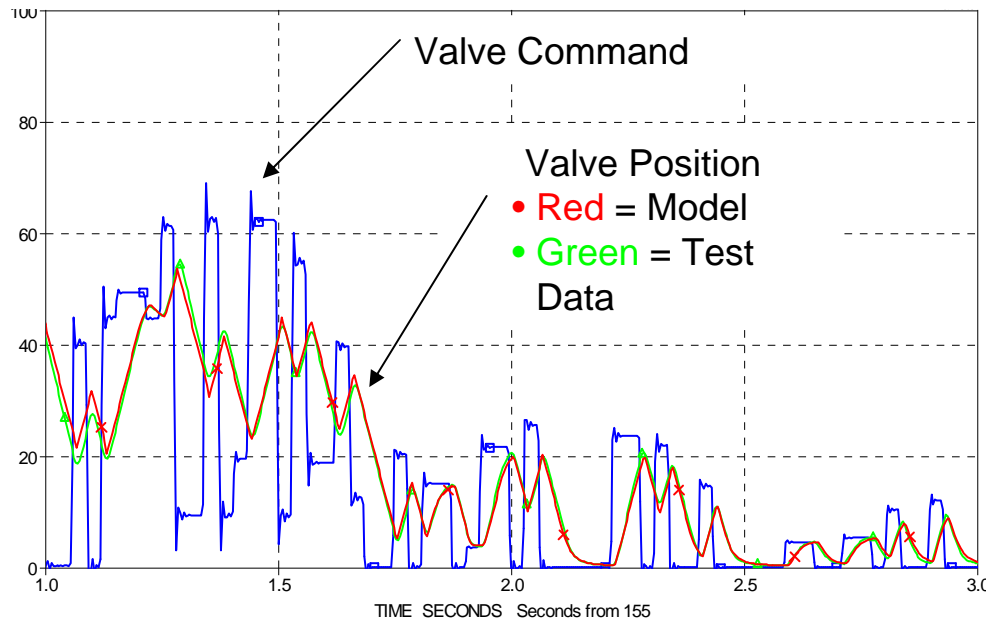




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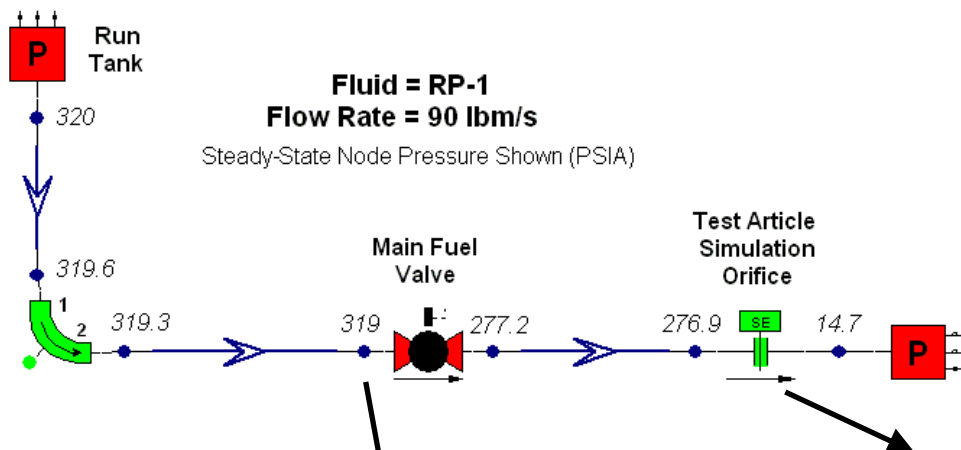
Pressure Control Valve (PCV) Model Developed & Validated



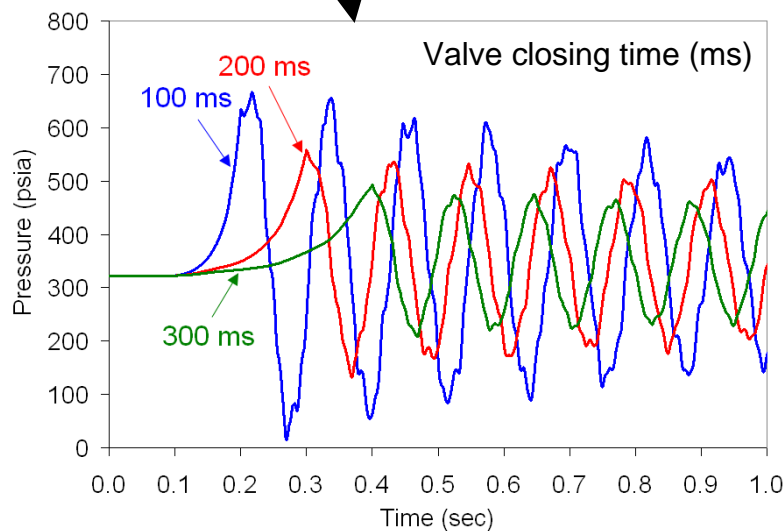
A Significant Advantage of the RPTA Model is the Coupling of Control Logic (Electro-Mechanical Process) with Thermodynamic Processes



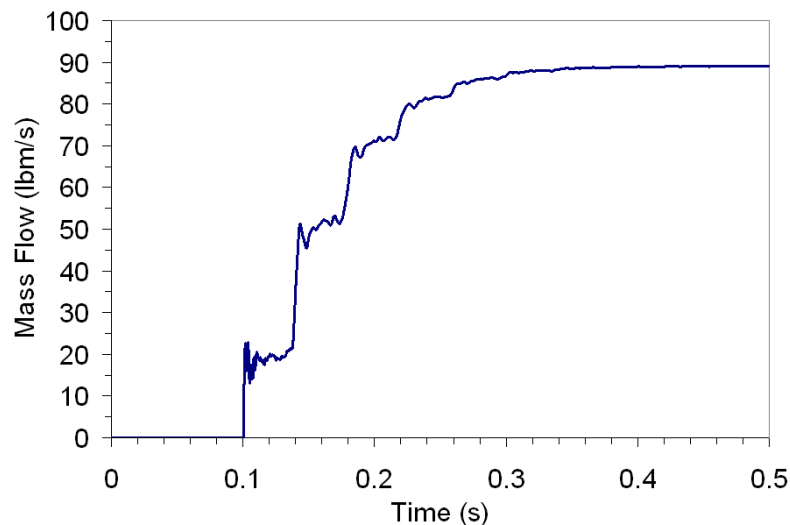
Comprehensive & Rapid Piping System Design & Analysis Capability



- Commercial Tools Employed to Augment Analysis
- Example: *FlowMaster* Piping System Analyzer
 - Allows for Steady-State or Transient Analysis, Compressible or Non-Compressible Flow
 - Includes Heat Transfer, Flow Balancing, Priming & Sizing Analysis



Water Hammer Effect Due to Rapid Closure of Main Fuel Valve



Propellant Flow to Test Article Due to Rapid Opening of Main Fuel Valve



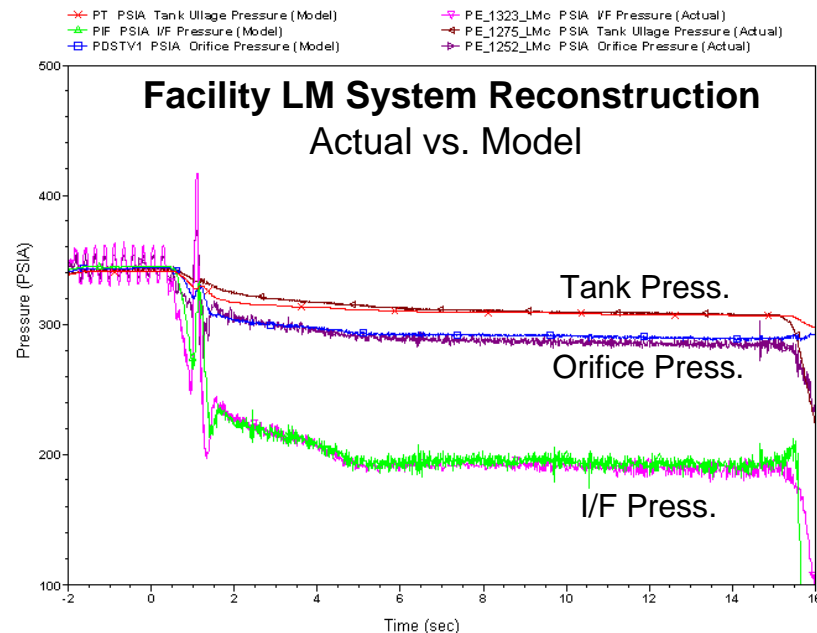
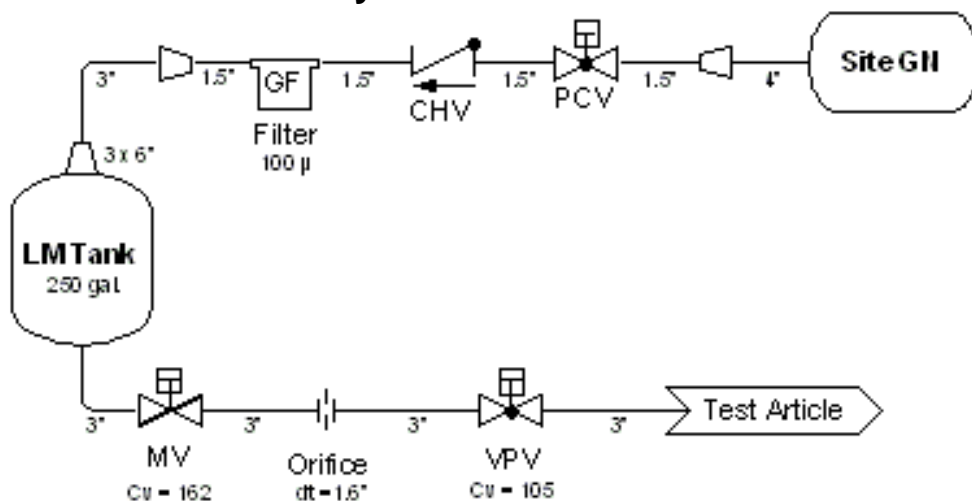
Recent LOX/Methane Testing at E-3

15 klbf Advent Engine Test Program – Nov 06

Facility Activated and Test Performed

- Liquid Methane (LM) & Liquid Oxygen (LOX) Propellants Used
- Facility Model Results and Facility Test Activation Results Agree Well
- Test Capability: ~25 seconds

LM System Schematic





14" Valve

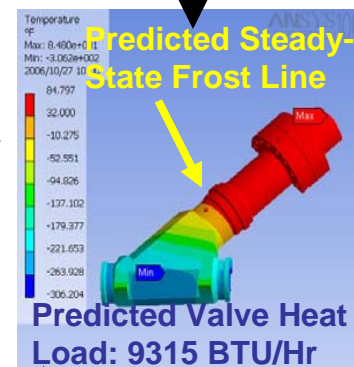
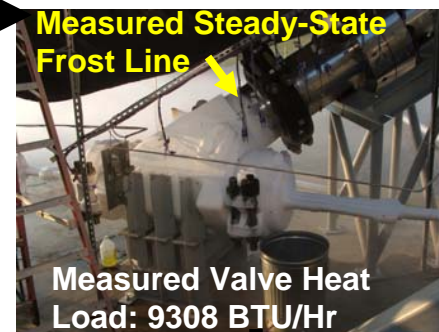
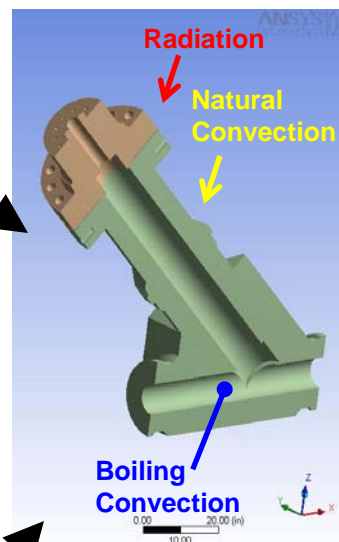
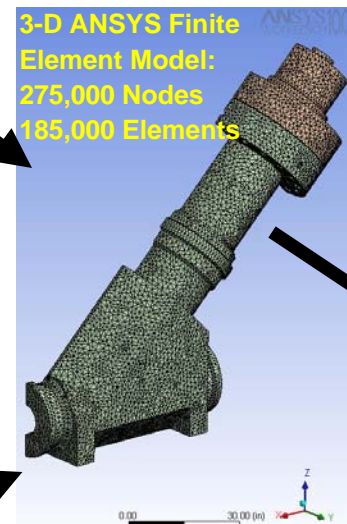
ANSYS Workbench Thermal Simulation

Geometry
Description

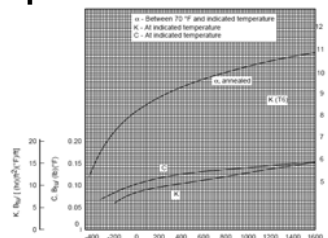
Analysis
Model

Loads & Boundary
Conditions

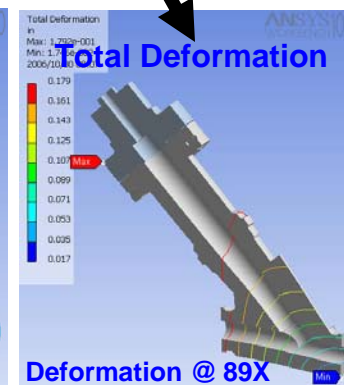
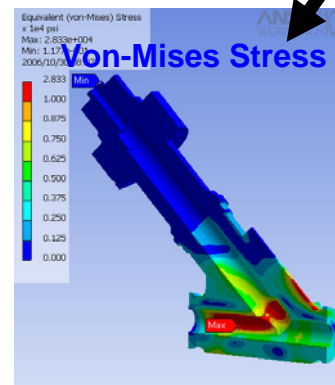
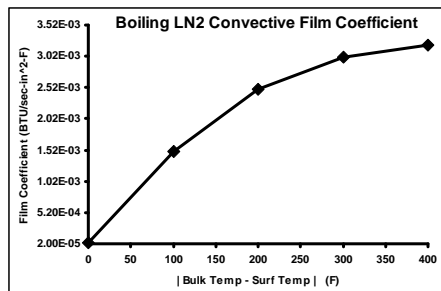
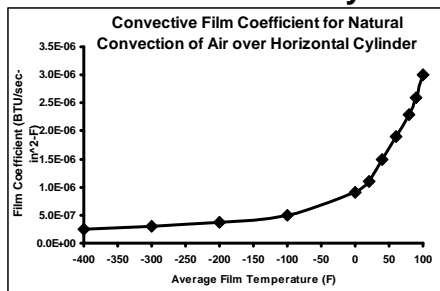
Validated Results



NIST / MIL-HDBK Temperature
Dependent Material Properties



Empirically Based Temperature Dependent
Boundary Condition Parameters





Computational Fluid Dynamics (CFD) Modeling

Employed CFD Code to Model E-1 High Pressure LOX Flow Capability

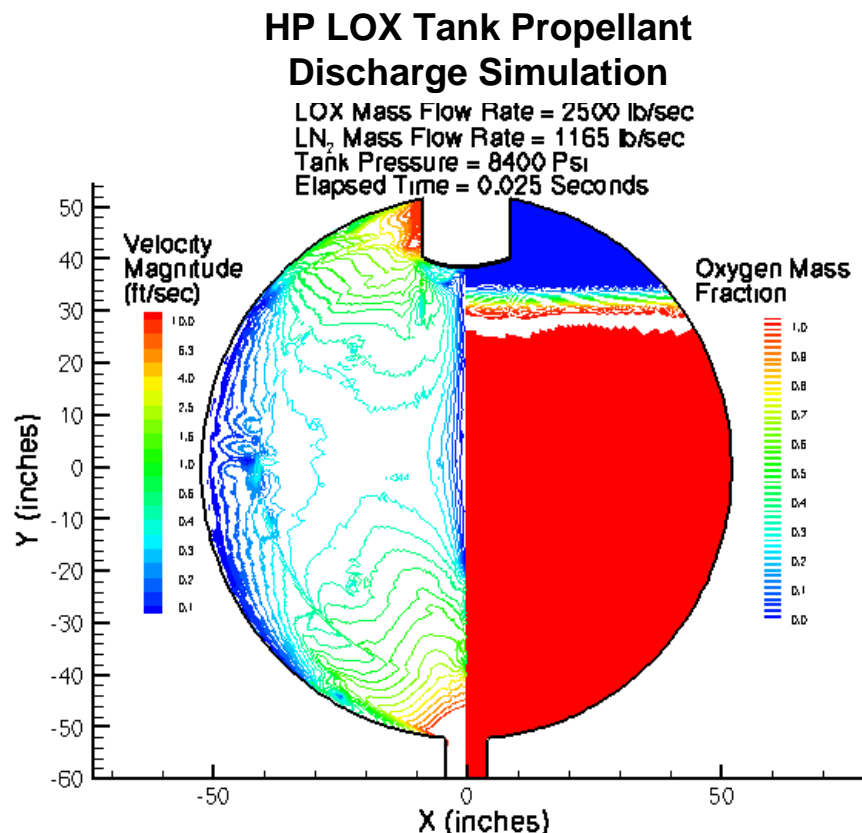
- CFD Investigations Indicate Pressurizing Gas Diffuser Flow Significantly Limits Flow Duration for High Flow Rate Cases

Analysis Boundary Conditions

- HP LOX Tank at E-1 Test Stand
- Flow Case Assessed
 - 2500 lb/sec LOX Discharge Rate
 - 8400 psi Tank Pressure Maintained During Propellant Discharge

Results & Observations

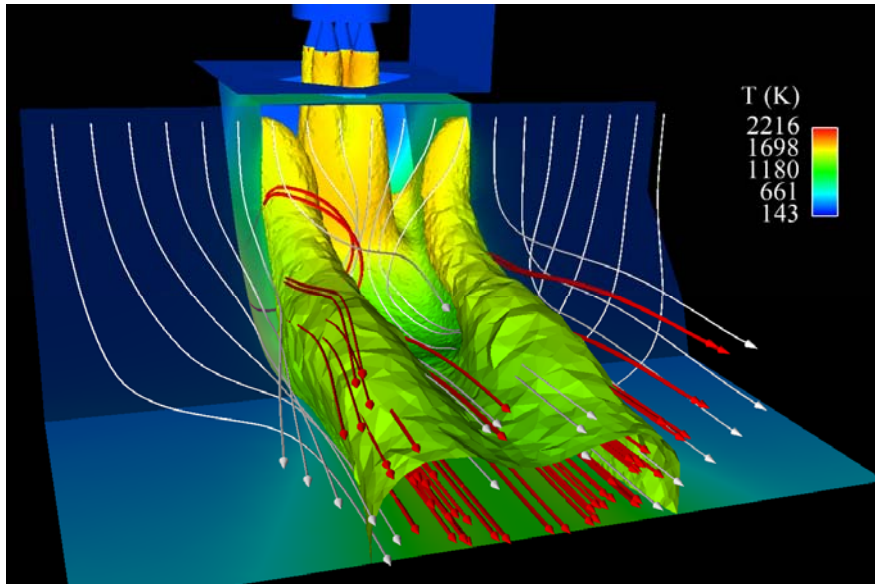
- GN Convective Mixing with LOX Propellant is Substantial
 - Only 50% Loaded LOX is Useable (<~2% N₂ Concentration)
- LOX Propellant Supply at Assessed Flow Rate & Pressure Limited to Approximately 4 seconds (vs an Estimated 10 seconds Determined Using Nominal Facility Pressurizing Gas & Propellant Supply Limits)





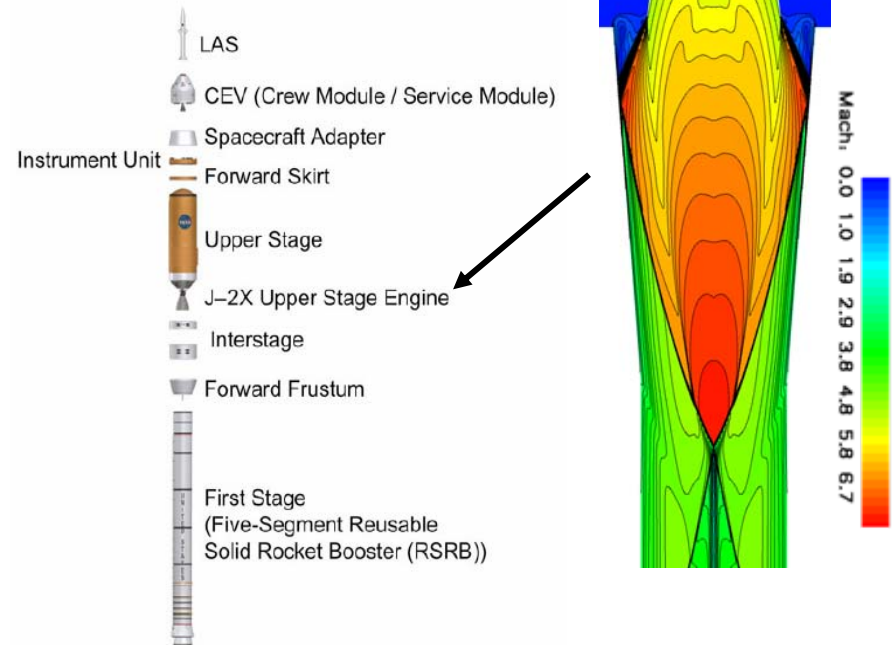
Advanced CFD Capability

- **Employ CFD Techniques to Support Propulsion Testing in the Following Areas:**
 - Cryogenic Propellant Delivery Systems (e.g., Run Tanks, Piping)
 - Cryogenic Control Devices (e.g., Valves)
 - Plume Modeling
- **Dedicated Computational Cluster (48 Dual Processors) at NASA SSC**



Computational Results of Conceptual Ares 5 Stage Test at SSC B-2 Test Stand

ARES I



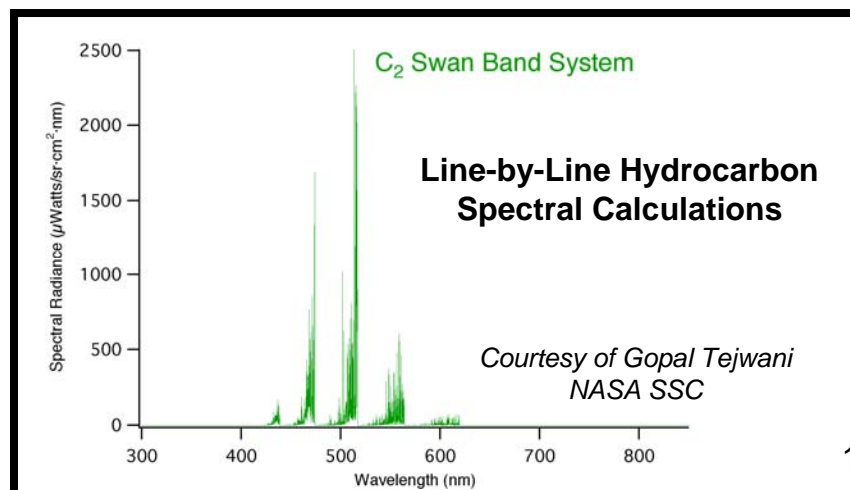
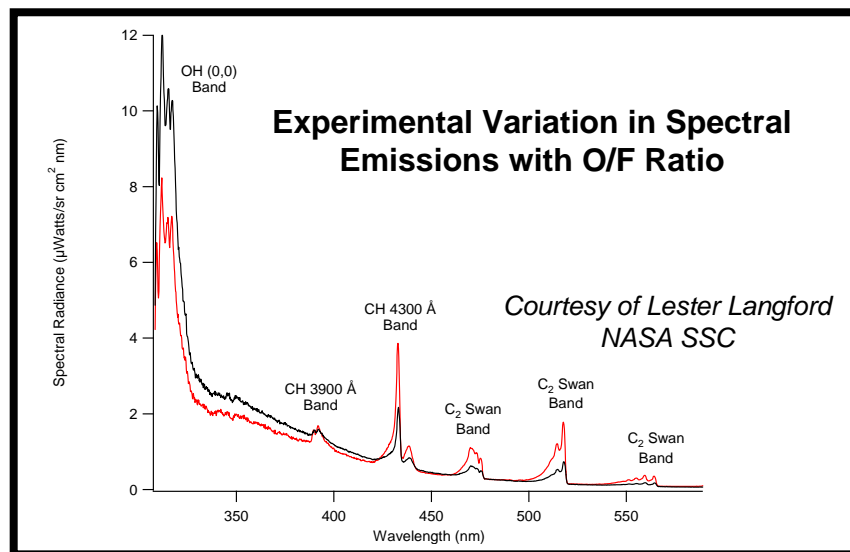
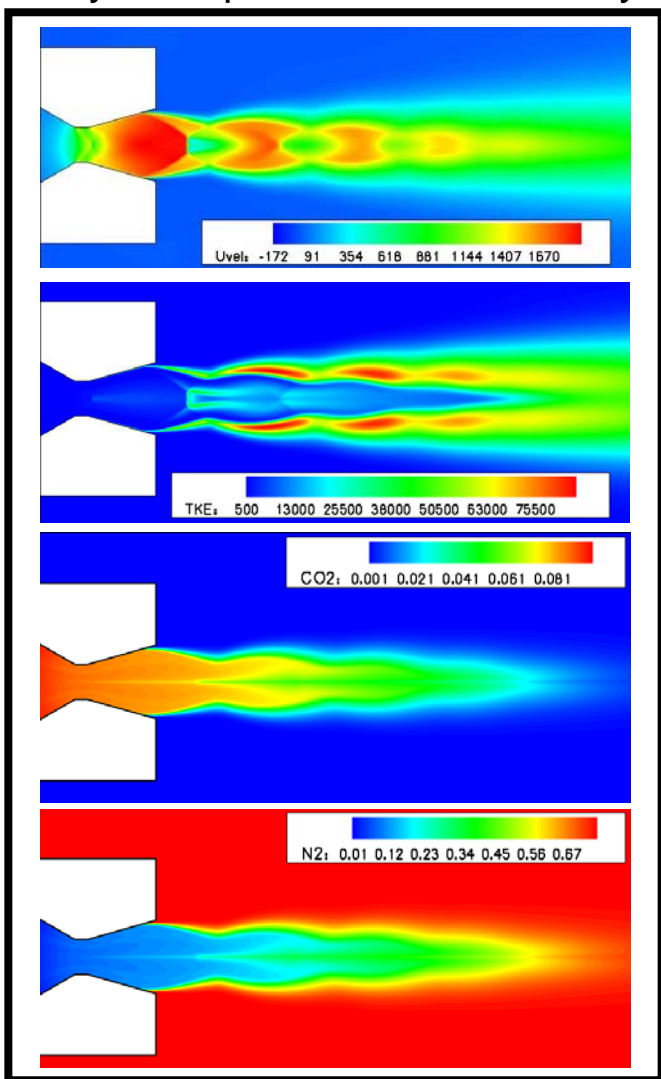
Computational Results of J-2X Altitude Diffuser Simulation (300 K-lbf)



NASA-SSC CFD Modeling Activities

MTTP Plume Simulations – CFD Model Validation

- CFD data was used to support parallel efforts in the experimental plume diagnostics and line-by-line spectral radiation analysis.





Summary

- SSC has Developed a Suite of Effective Analytic Modeling and Analysis Tools Providing High Fidelity Assessment of Test Stand Performance
 - Rocket Propulsion Test Analysis (RPTA) Model, a 1-D Propellant System Analyzer
 - CFD Applied to Select Propulsion Test Situations
 - Finite Element Analysis (ANSYS/CFX)
- Analytic Tools Exercised Regularly on a Variety of Propulsion Test Projects by Experienced Analysts
 - Active Test Facilities (1.0 to 1.5 Mlbf Thrust, 8500 psi LOX/LH/RP-1 Supply)
 - Active Test Projects (e.g., J-2X PPA & Engine, A-3, Chemical Steam Generator)

For Additional Information/Discussion Please Contact :

David Coote 228-688-1056, Email: David.J.Coote@nasa.gov

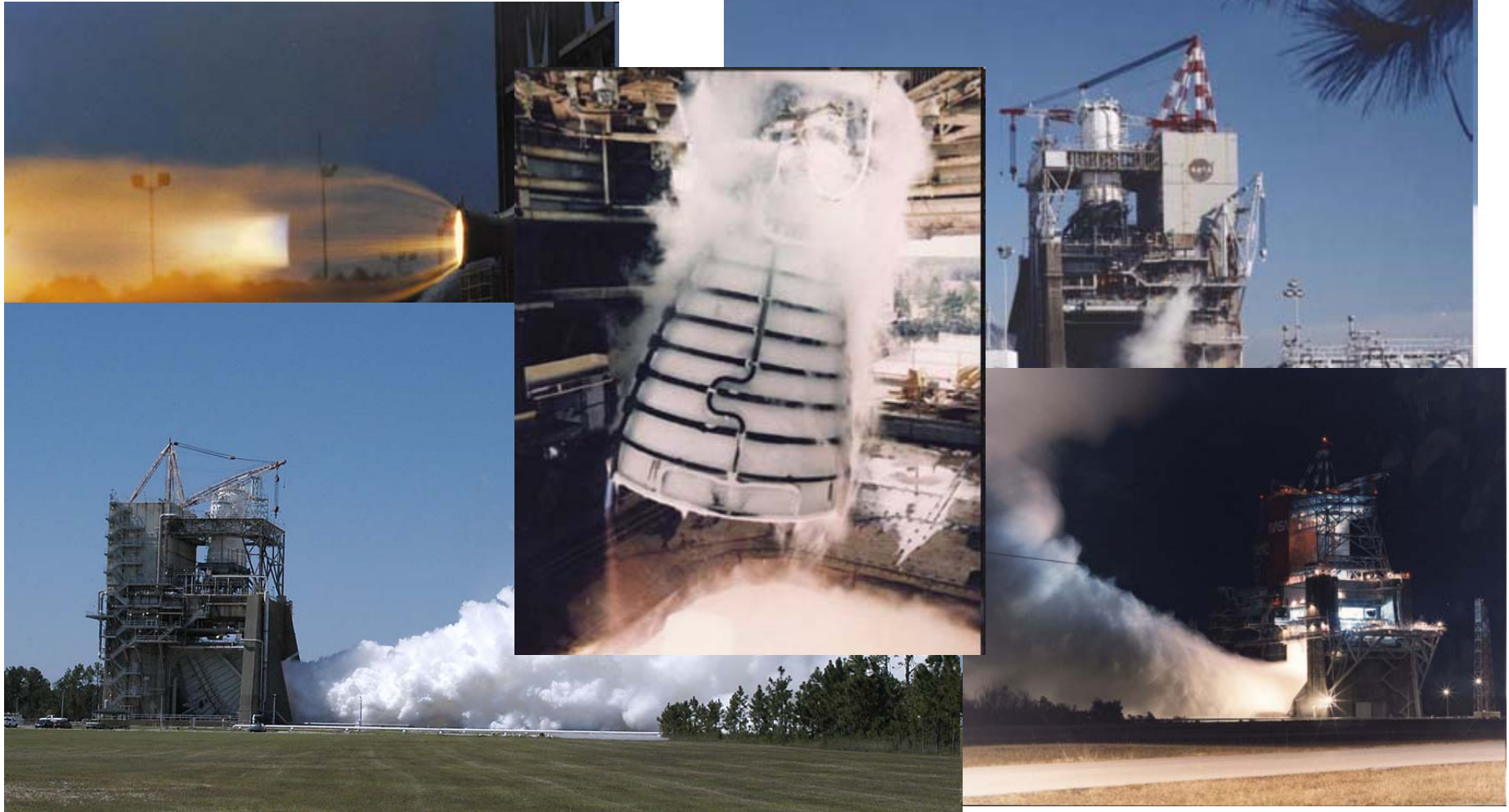
Harry Ryan 228-688-2757, Email: Harry.M.Ryan@nasa.gov



Liquid Propellant System Modeling



*NASA Stennis Space Center (SSC)
Engineering & Test Directorate (ETD)
Design & Analysis Division
January 21, 2009*





Liquid Propellant System Modeling

Summary



Background

- The Rocket Propulsion Test Analysis (RPTA) Model Is an Effective Analytic Modeling and Analysis Tool Providing High Fidelity Assessment of Propellant System Performance
 - RPTA Adapted From a Model Originally Developed for Shuttle & X-33 Propellant System Performance Analyses
 - RPTA Model Application :
 - Used Extensively for
 - SSC Propellant System Analysis (e.g., Test Project (e.g., J-2X PPA, A-3, Chemical Steam Generator (CSG)) Facility Development, Activation
 - Test and Facility Maintenance and Upgrades Investigations, Studies and Trades
 - Recently Used for Systems Sizing and Operations Performance Analysis of the LOX and LCH4 Tanks for the Lunar Surface Ascent Module Team Study (May 2007)
 - Currently Being Employed to Evaluate Propellant Load Operations and Performance of the Ares I LOX & LH Tank for MSFC Team (January 2009)
 - A Graphical User Interface (GUI) Developed for the RPTA Model to Allow Ease of Use of the Model

Benefits

- Propellant System Modeling Allows For A Timely & Cost-Effective Assessment of the Propellant System Performance
- Integrated Performance Modeling Capabilities Has Translated to Efficient Test Facility Design, Activation & Test Operations

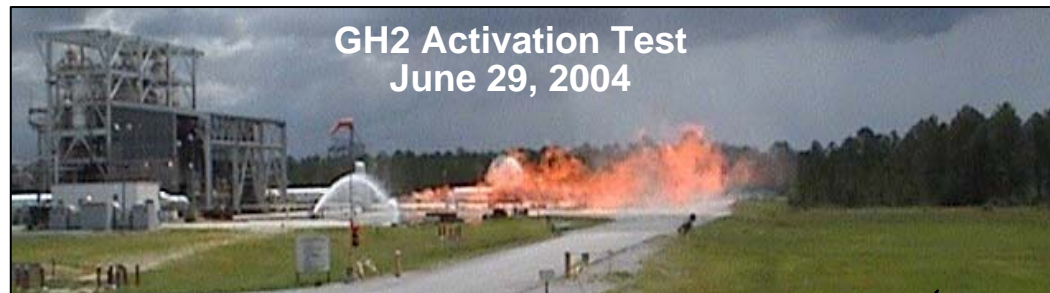


Integrated Facility Simulation and Analysis

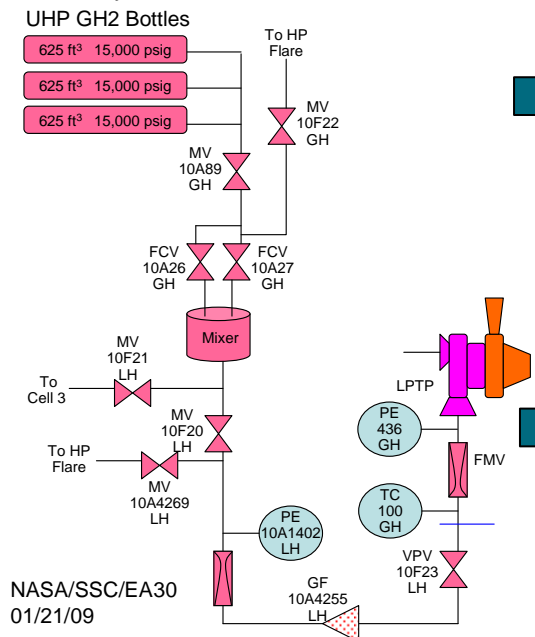


- Analytic Tools Available for Test Facility/Project Modeling & Analysis
- Comprehensive Propellant System Thermodynamic Modeling & Test Simulation

Integrated Performance Modeling Capabilities Substantially Improves Understanding & Knowledge of Test Systems Performance that has Translated to Efficient Test Facility Design, Activation & Test Operations

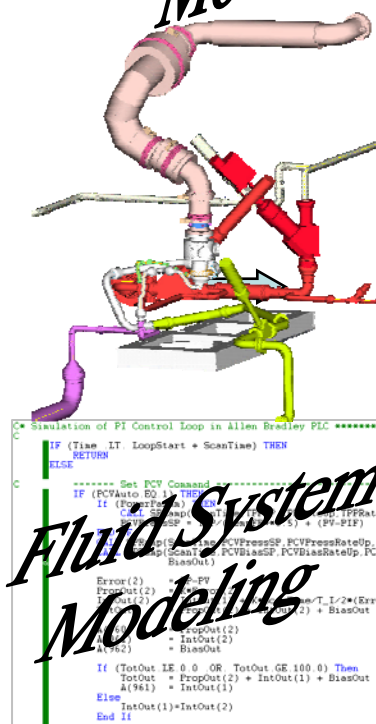


System Design



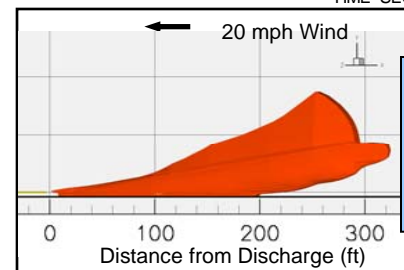
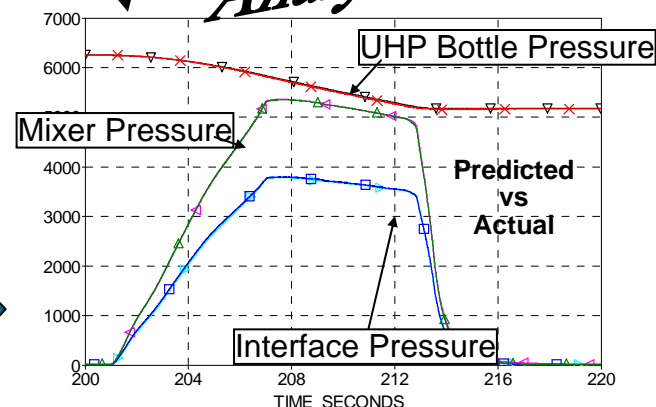
NASA/SSC/EA30
01/21/09

Modeling



Fluid System Modeling

Test and Data Analysis



Advanced Capabilities in CFD Modeling & Analysis

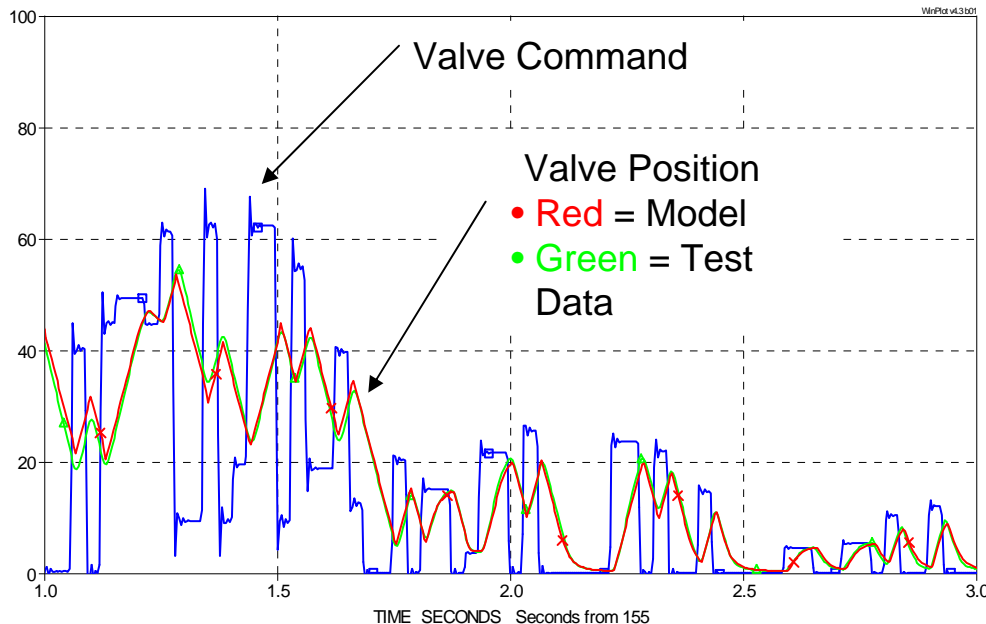


Rocket Propulsion Test Analysis (RPTA) Model



- Temporal Transient Thermodynamic Modeling of Integrated Propellant Systems
 - Thermodynamic Control Volume Solver Model Accurately Models Cryogenic and Storable Propellant and High-Pressure Gaseous Systems.
 - Includes High-Fidelity Pressure Control Valve (PCV) & Closed Loop Control System Algorithms
- Model Validated Through Numerous Test Data Reconstructions
 - J-2X PPA-1A, IPD Fuel Turbopump, RS-84 Sub-Scale Pre-Burner, RS-83 Pre-Burner Cold Flows, SSME Flowliner Activation & IPD Engine System

Pressure Control Valve (PCV) Model Developed & Validated



A Significant Feature of the RPTA Model is the Coupling of Control Logic (Electro-Mechanical Process) with Thermodynamic Processes



RPTA Model GUI Development



Background

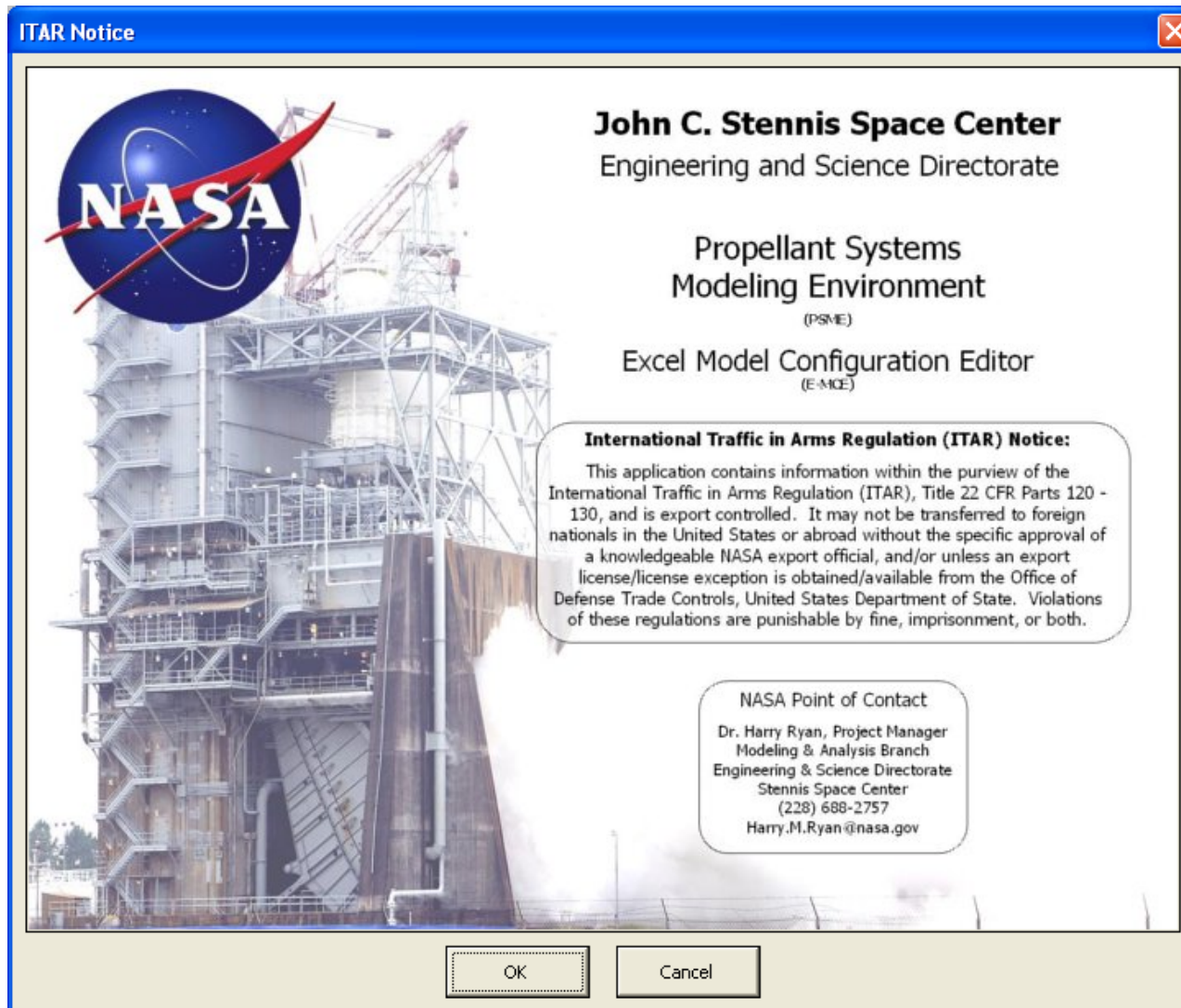
- The RPTA Model provides focused and detailed analysis of a propellant system, from a single propellant tank to an integrated propellant system that includes
 - Propellant Tank
 - Facility Propellant Storage Tank
 - Pressurant Supply and System Control
 - Propellant Feed System
 - Test Article Simulation
- Requires a substantial amount of data defining boundary and initial conditions that requires esoteric knowledge of the model's data file structure and the model's code not required of the typical user
 - Following is a quick view of the model parameter data sets involved

6



Propellant Systems Modeling Environment

PSME





GUI interface Significantly Simplifies Model Set-up



The image displays a GUI interface for model setup, divided into two main sections: a schematic diagram and a configuration table.

Schematic Diagram: The top section shows a diagram of the system. It includes four yellow rectangular tanks labeled "Pressurant Tanks" connected to a horizontal "Pressurant Piping" line. This line leads to a "Pressurant Control Valve" and then to a large cylindrical "Run Tank". A "Home" button is located in the top left corner of the schematic area.

Configuration Table: The bottom section is a table with two main tabs: "Initialization Information" and "Configuration Information".

Initialization Information		
Tank Liquid Type	2	
Initial Run Tank Inner Wall Surface Temperature	530.0	R
Initial Run Tank Ullage Temperature	530.0	R
Initial Run Tank Ullage Volume	3250.0	ft3
Tank Pressure	15.0	psia
Temperature of Tank Liquid	163	R

Configuration Information		
Tank Baffle Area to Mass Ratio	0.0023	ft2/lb
Total Bubble Volume in Liquid	0.	ft3
Tank Stretch due to Pressure	0.	ft3/psi
Change in Volume due to Change in Tank Temp	0.	ft3/R
Total Tank Volume	3825.0	ft3
Nominal Tank Pressure	14.7	psia
Nominal Tank Temperature	530.0	R
Mass of Pressurant Gas in Ullage	30.0	lb
Constant for natural convection: ullage to liquid	0.09	
Constant for natural convection: ullage to wall	0.12	
Constant for forced convection: ullage to liquid	0.23	
Constant for forced convection: ullage to wall	10.	
Constant for natural convection: bulk liquid to surface	0.13	
Constant for natural convection: bulk liquid to wall	0.13	
Constant for forced convection: entering gas to diffuser	3.70	
Constant for forced convection: ullage to baffles	0.06	
Diffuser surface area	0.555	ft^2
Tank Runtable File Name	RUNTABLES.dat	
Use Temporal Transient Wall Temp File	F	
Evaluate Wall Temp	T	
Mass of Diffuser	311.	lbm
Determine Energy Transfer from Splashing	F	

RV Pressure Table (psia)

-1.0
50.0
4300.0
5300.0
5400.0
10000.0

RV CdA Table

17.8
17.8
17.8
17.8
17.8

Commands Panel: A vertical panel on the right side of the interface contains several buttons: "Select Model Configuration", "Run", "View Results", "Save Changes", "View Configuration Files", "MCM Admin", and "Exit".

Metadata: A box in the top right corner displays the following information: Name: test, Date: 11/4/2008 1:10:41 PM, System: A3_CSG_IPA, Type: Liquid, and State: (indicated by a lock icon).



Provides Access to All Configuration Data



MCE - View Configuration Files

Model Configuration Files

Model Test: Date:

Config | Initial | PLC | PCV | RunTables | Tables | TankMDF | Trajectory | VPV_Cv

```
$DATA
IN_OUTPUT=TANKMDF.DAT
IN_TABLES=TABLES.DAT
LDV=F
LTGE=F
LVDL=F
POW=0.33,0.33,0.8,0.8,0.33,0.33,0.8,0.33,
WDHEI=0.
!ACDEF=0.09,0.12,0.23,10,0.13,0.13,3.70,0.06,
TA=530.
!VOLSPH=5611.97665450645
ACDEF=0.,0.0,0.0,0.,0.,0.,0.,0.,
ADIF=0.555
ALT=0.
ATOM=0.0023
BOTMAT=3
BUBV=0.
CRAD=0.0000000000000384
DGHEBTL=135.282990179341
VGHEBTL=1002.
DIAL=4.04,10.,
DTSOP=0.
DVDTT=0.
GAMMA=1.4
IGAS=5
PRTHICK=2.25
IN_TANK='RUNTABLES.dat'
IRTPLOT=0
LHEAT=F
LPA=F
LSPL=F
MONTING=0
```

OK Cancel

View Configuration Files

Pressurant Control Valve

Run Tank

Run Piping

Test Conditions

Trajectory Data

Name: test
Date: 11/4/2008 1:10:41 PM
System: A3_C50_IPA
Type: Liquid
State:

Commands:

Select Model Configuration

Run

View Results

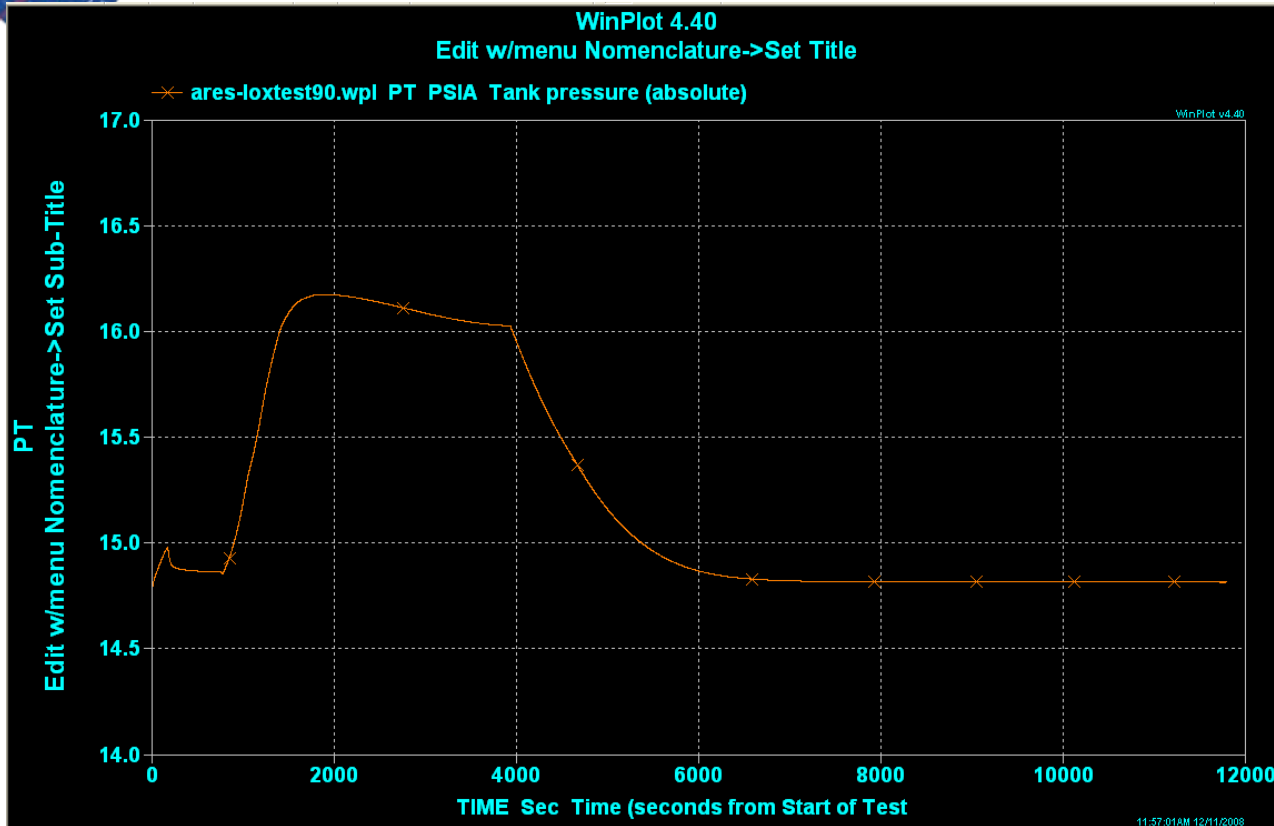
Save Changes

MCM Admin

Exit



Model Execution & WinPlot Results



test
11/4/2008 1:10:41 PM
A3_CSG_IPA
Liquid

Commands
Select Model Configuration

Run

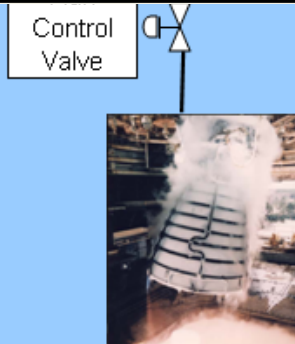
View Results

Save Changes

View Configuration Files

MCM Admin

Exit



PLC Control



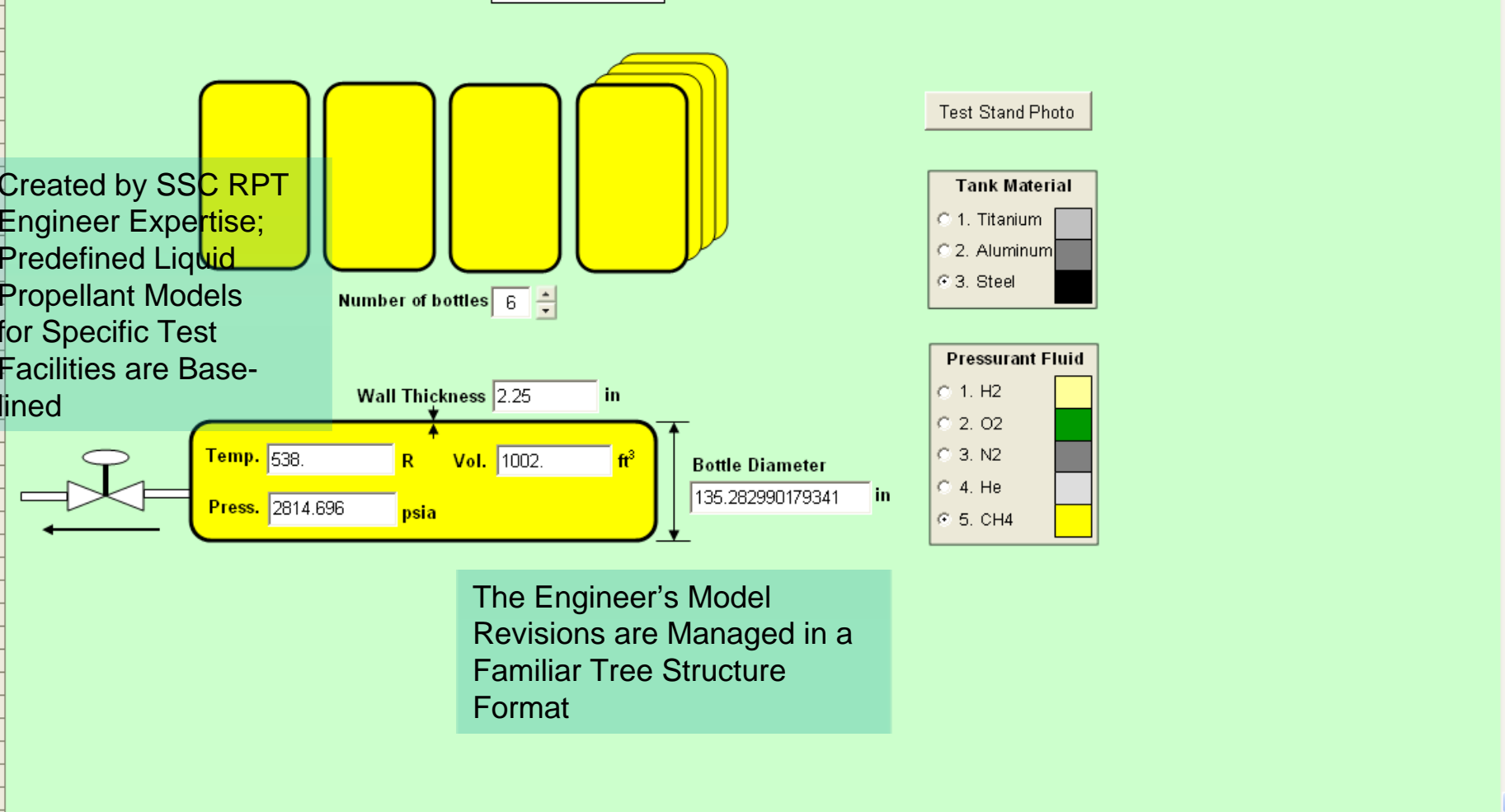
Propellant Systems Modeling Environment Model Library & Configuration Editor



Interactive Schematic Integration Prototype

	A	B	C	D	E	F	G	H	I	J	K	L
1		Home										

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1		Pressurant Tanks														



Created by SSC RPT
Engineer Expertise;
Predefined Liquid
Propellant Models
for Specific Test
Facilities are Base-
lined

The Engineer's Model
Revisions are Managed in a
Familiar Tree Structure
Format



Propellant Systems Modeling Environment

Gas Model Support Scheduled in Early 2009



	A	B	C	D	E	F	G	H	I	J	K	L
1		Home										
2												
3												
4												
5												
6	A	B	C	D	E	F	G	H	I	J	K	L
7		TEST CONDITIONS (G)										
8												
9												
10												
11												
12												
13												
14												
15		Winplot Closeout Time	10.0		sec							
16		Solver Time Step	0.0005		sec							
17		Winplot File Write Interval	0.01		sec							
18		Screen output time interval	10.		sec							
19												
20		Trajectory File Name	Trajectory.csv		n/d							
21		Bottle Wall Mat'l Properties	WALL_DATA.dat		n/d							
22		Winplot File Name	Gas-Output.wpl		n/d							
23												
24												
25		Winplot Start Time	-20.		sec							
26		Pressurant Spec...	3		n/d							
27		Assess Heat Transfer Across Pressurant Bottle Wall?	T		n/d							
28		Heat Transfer Coefficient Multiplier	1.00		n/d							
29		Add'l External Heat Soak to Bottles	0.0		Btu/s							
30												
31		Pressurant Bottle Charge Supply Pressure	1000.		psia							
32		Pressurant Bottle Charge Supply Temp	500.		R							
33												
34		Pressure D/S of Regulator / PCV	14.7		psia							
35		Regulator / PCV Pressure Cycling?	554.45		R							
36												
37		Line Discharge Pressure	14.7		psia							
38												
39		Vent Relief Cracking Pressure	4950.		psia							
40		Assess Pressurant Tank Pressure Cycling?	T		n/d							
41												
42		Fluid Enveloping Pressurant Tank	3		n/d							
43		Pressurant Tank External Pressure	14.7		psia							
44		Pressurant Tank External Temperature	546.5		R							
45		Fluid State	0		n/d							
46												
47												
48		Regulated Outflow?	F		n/d							
49		Accel Force on Bottle	32.174		(lbm/ft)(lbf/s ²)							
50												
51												
52												
53												
54												
55												
56												
57												
58												
59												
60												
61												
62												
63												
64												
65												
66												
67												

Home

Winplot Closeout Time 10.0 sec

Solver Time Step 0.0005 sec

Winplot File Write Interval 0.01 sec

Screen output time interval 10. sec

Trajectory File Name Trajectory.csv n/d

Bottle Wall Mat'l Properties WALL_DATA.dat n/d

Winplot File Name Gas-Output.wpl n/d

Winplot Start Time -20. sec

Pressurant Spec... 3 n/d

Assess Heat Transfer Across Pressurant Bottle Wall? T n/d

Heat Transfer Coefficient Multiplier 1.00 n/d

Add'l External Heat Soak to Bottles 0.0 Btu/s

Pressurant Bottle Charge Supply Pressure 1000. psia

Pressurant Bottle Charge Supply Temp 500. R

Pressure D/S of Regulator / PCV 14.7 psia

Regulator / PCV Pressure Cycling? 554.45 R

Line Discharge Pressure 14.7 psia

Vent Relief Cracking Pressure 4950. psia

Assess Pressurant Tank Pressure Cycling? T n/d

Fluid Enveloping Pressurant Tank 3 n/d

Pressurant Tank External Pressure 14.7 psia

Pressurant Tank External Temperature 546.5 R

Fluid State 0 n/d

Regulated Outflow? F n/d

Accel Force on Bottle 32.174 (lbm/ft)(lbf/s²)

Home

Exit

Propellant-Aware,
PSME Detects
Whether Model
Selections are Liquid
or Gas
and Serves up the
Correct Executable
and Parameter Editing
Screens to the
Engineer

PSME Provides Automated
Validation Checking of
Parameter Fields with
Defined Value Types and/or
Min / Max Ranges for Both
Liquid and Gas



SSC Engineering & Test Directorate (ETD)



For Additional Information/Discussion Please Contact :
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